



# **The Wind Erosion Prediction System**

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## **WEPS 1.0**

## **User Manual DRAFT**

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September 2003



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## **Preface and Acknowledgments**

### **Preface**

Wind erosion is a serious problem on agricultural lands throughout the United States as well as the world. The ability to accurately predict soil loss by wind is essential for, among other things, conservation planning, natural resource inventories, and reducing air pollution from wind blown sources. The Wind Erosion Equation (WEQ) is currently widely used for assessing average annual soil loss by wind from agricultural fields. The primary user of WEQ is the United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). When WEQ was developed more than 35 years ago, it was necessary to make it a simple mathematical expression, readily solvable with the computational tools available. Since its inception, there have been a number of efforts to improve the accuracy, ease of application, and range of WEQ. Despite these efforts, the structure of WEQ precludes adaptation to many problems.

The USDA appointed a team of scientists to take a leading role in combining the latest wind erosion science and technology with databases and computers, to develop what should be a significant advancement in wind erosion prediction technology. The Wind Erosion Prediction System (WEPS) incorporates this new technology and is designed to be a replacement for WEQ.

Unlike WEQ, WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, management, and erosion. WEPS 1.0 consists of the WEPS science model with a user friendly program that has the capability of simulating spatial and temporal variability of field conditions and soil loss/deposition within a field. WEPS 1.0 can also simulate simple field shapes and barriers on the field boundaries. The saltation/creep, suspension, and PM10 components of eroding material also can be reported separately by direction in WEPS 1.0. WEPS 1.0 is designed to be used under a wide range of conditions in the U.S. and is adaptable to other parts of the world. For further information regarding WEPS contact:

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## Acknowledgments

The Wind Erosion Prediction System (WEPS) resulted from the work of many individuals representing several agencies and institutions. In particular, appreciation is extended to the WEPS Core Team members: D.V. Armbrust (retired), J.D. Bilbro (retired), G.W. Cole (retired), A.A. Durar, F. Fox, D.W. Fryrear (retired), R.B. Grossman, L.J. Hagen, L. Lyles (retired), A. Retta, A. Saleh, H.H. Schomberg, H.R. Sinclair, E.L. Skidmore, J.L. Steiner, J. Tatarko, P.W. Unger (retired), S. Van Donk, and T.M. Zobeck; the Agency liaisons to the Core Team, including: M.S. Argabright, NRCS (retired), H. Bogusch, NRCS, R. Dunkins, EPA, and C. Voight, BLM; the ARS NPL including: C.R. Amerman (retired), S. Rawlins (retired), W.D. Kemper (retired), and Mark Wertz; and NRCS leaders including K. Flach (retired), D. Schertz (retired), G. Tibke, and D. Woodward.

Gratitude is also expressed to the many cooperators and other individuals who have contributed to the development of WEPS through their valuable research, criticisms, and comments. These individuals include: J.K. Aase, A. Black, W. Blackburn, P. Bullock, D.J. Ding, G. Foster, D.A. Gillette, J. Gregory, J.R. Kiniry, D. Koeltzow, J. Laflen, J.A. Lamb, F. Larney, J.B. Layton, M.J. Lindstrom, S.D. Merrill, N. Mirzamostafa, D.L. Mokma, A. Moulin, C. Meyer, A. Nicks, K.N. Potter, R. Savabi, K. Saxton, J. Stout, E.D. Vories, and J. Williams. The work of L. Ascough, A. Hawkins, W. Gu, S. Kaul, S. Kota, S. Liu, W. Rust, and M. Uttarwar is also greatly appreciated.

Recognition is given to the support of many agencies and universities which made WEPS a reality. These include the USDA Agricultural Research Service, USDA Natural Resources Conservation Service, the US Department of Interior - Bureau of Land Management, the US Forest Service, the US Environmental Protection Agency, the US Army Corps of Engineers, and Kansas State University.

The contribution of the NRCS state and field offices and other individuals who participated in the WEPS validation studies is also recognized.

Finally, acknowledgment is made of the many other individuals who have made this release of WEPS possible by reviewing this document and those who contributed through fundamental research on which many of the underlying concepts of WEPS are based.

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# INTRODUCTION





# Introduction

## How to Use This Document

The Wind Erosion Prediction System or 'WEPS' is a process based, daily time-step, wind erosion simulation model. It represents the latest in wind erosion prediction technology and is designed to provide wind erosion soil loss estimates from cultivated, agricultural fields. WEPS 1.0 consists of the computer implementation of the WEPS science model with a graphical user interface designed to provide an easy to use methods of providing inputs to the model and obtaining output reports. WEPS was developed by the Wind Erosion Research Unit (WERU) of the United States Department of Agriculture, Agricultural Research Service.

The WEPS 1.0 User Manual is designed to provide information to different levels of users. The minimum computer requirements and the steps to install WEPS onto your computer are described in this chapter (Chapter 1). Those users who are completely new to WEPS should start with Chapter 2, the "Beginners Guide". It is recommended that, as a minimum preparation to use WEPS, the user should read the "Overview of the Wind Erosion Prediction System". Once WEPS has been installed on your computer, the user should learn how to make a simple simulation run using the "Quick Start for WEPS 1.0". For users interested in more details of the science behind WEPS, the chapter titled "Science - How WEPS Simulates Wind Erosion" (Chapter 3) is recommended. An even more detailed description of the science of the WEPS model is available in the "WEPS Technical Description" which can be obtained from WERU. More experienced users should become familiar with Chapter 4, "How to Operate WEPS", which goes into detail of how to use all of the capabilities of WEPS 1.0. These details are also available in the 'Online Help', accessible through the toolbars on the WEPS 1.0 interface screen. Chapter 5, "Using WEPS in Conservation Planning" contains sections on 'Interpreting Outputs', 'Special Field Configurations', and 'Using Barriers for Erosion Control in WEPS'. Chapter 5 also has Example problems which guides the user through exercises that describe how to use WEPS to design conservation systems. An index to the WEPS User Manual is available in Chapter 6. Finally, the "Appendices" Chapter 7 contains the text for the WEPS tutorials which are available on CD-ROM. These texts will be useful for those who are not able to listen to the audio portion of the tutorials and want to 'read along'. The Appendix also contains information for more advanced users such as a listing of 'Submodel Report Flags and Command Line Options' and WEPS 'Databases'. Submodel Report Flags and Command Line Options are set under the 'Configurations' tabs available through the Main Screen of the interface. Certain permissions may be required to alter some of these flags and options. Databases are described for the Weather, Soil, Crop, Management, and Operations sections of WEPS.

Throughout this manual, the term “user” refers to the person(s) using WEPS 1.0 to set up and make a simulation run. “Operator” refers to the producer or land manager whose actual field is being simulated with WEPS. This manual contains many graphics which are examples of what can be seen on the computer screen using WEPS. In addition, WEPS will continually be improved and the screens may change. Therefore, the user may or may not see the exact same screens as those illustrated in this manual.

WEPS is a model developed primarily for the use of the USDA, Natural Resources Conservation Service (NRCS). As such, many of the capabilities of WEPS reflect the needs of NRCS for use in cultivated agricultural systems. However, WEPS has capabilities to be used in other situations where wind affected soil movement is a problem. Please contact WERU if you wish to use WEPS to predict erosion for situations other than traditional cultivated agricultural systems.

## Minimum Computer Requirements

The minimum recommended requirements to install and operate WEPS1.0 effectively are: A personal computer (PC) with Windows 95/98 (48 Mb RAM), Windows NT (64 Mb RAM), Windows 2000 (192 Mb RAM), or Windows XP (256 Mb RAM); 300 MHz Pentium; 150 Mb free disk space on the hard drive; a CR-ROM drive for installation; and a VGA color monitor with a minimum screen resolution of 800 x 600 pixels. Contact WERU if you need assistance.

## Installation

For Windows operating systems, insert the WEPS1.0 CD into the CD-ROM drive. Click [Start] [Run] and enter {w:/setup} where “w” represents the drive letter for your CD-ROM drive. Follow the instructions on the screen. NOTE: See the “readme” file for up-to-date installation instructions for this CD-ROM. Note that on Windows NT, 2000, and XP machines, the user must either be logged in as “administrator” or have sufficient privileges to successfully install WEPS 1.0. The WEPS install program will inform the user attempting installation if they do not have sufficient privileges to perform installation.

WEPS1.0 is also available for download on the WERU web site at <http://www.weru.ksu.edu/weps>. Follow the link for WEPS download and fill out the WEPS Download Registration form. By filling out the registration form, WERU will provide notices of updates to the model. The download file consists of an executable file which will install WEPS onto your Windows computer. Contact WERU if you need assistance at:

Phone: 785-537-5559  
E-mail: [weps@weru.ksu.edu](mailto:weps@weru.ksu.edu) .





# BEGINNERS GUIDE





## An Overview of the Wind Erosion Prediction System

### Introduction

The Wind Erosion Prediction System (WEPS) is a process-based, daily time-step model that simulates weather, field conditions, and erosion. WEPS development was in response to customer requests for improved wind erosion technology. It is intended to replace the predominately empirical Wind Erosion Equation (WEQ) (Woodruff and Siddoway, 1965) as a prediction tool for those who plan soil conservation systems, conduct environmental planning, or assess offsite impacts caused by wind erosion.

WEPS development involves an ARS-led, national, multi disciplinary team of scientists. It has a multi-agency commitment consisting of the Agricultural Research Service (ARS), Natural Resource Conservation Service (NRCS), and Forest Service (FS) from the U.S. Department of Agriculture, along with the Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers, and Bureau of Land Management (BLM).

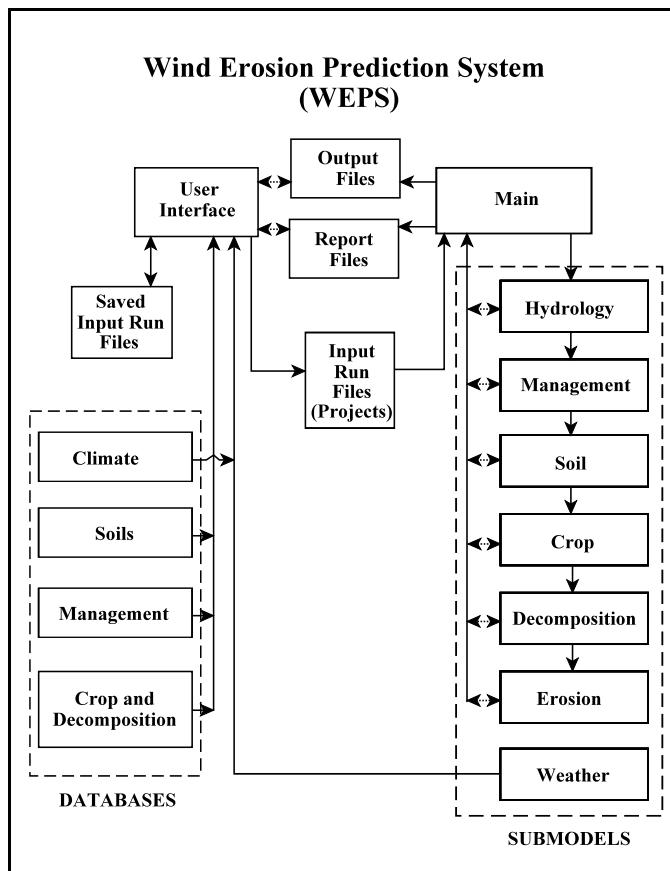


Figure 2.1. Structure of the WEPS model.

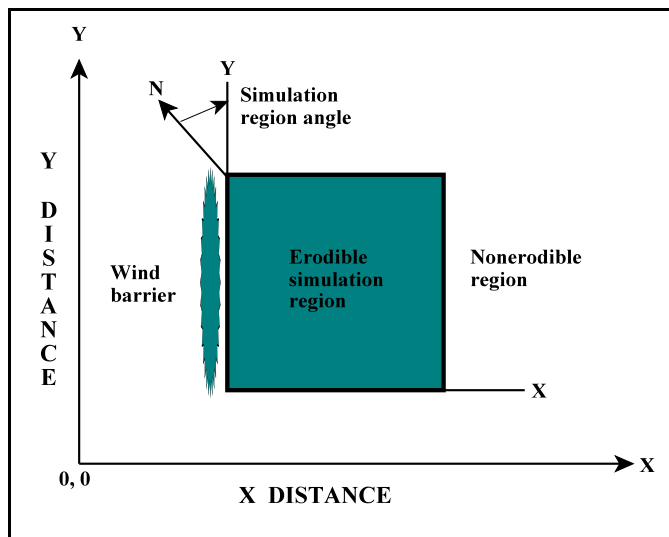
### Objectives

The purposes of WEPS are to improve assessment of soil loss by wind from agricultural fields and to provide new capabilities such as assessing plant damage, calculating suspension loss, and estimating PM-10 emissions from the field.

### Background

Soil erosion by wind is initiated when the wind speed exceeds the saltation threshold speed for a given soil and biomass condition. After initiation, the duration and severity of an erosion event depend on the wind speed and the evolution of the surface condition. Because WEPS is a continuous, daily time-step model, it simulates not only the basic wind erosion processes, but also the processes that modify a soil's susceptibility to wind erosion.

The structure of WEPS is modular and consists of a user-interface, a MAIN (supervisory) routine, seven submodels, and four databases (Fig. 2.1). The user-interface is used to create input files with information from the databases and the weather generator. In a practical application, new input files usually will be created by using previous input files as templates modified within the user-interface.



**Figure 2.2.** WEPS simulation geometries.

### Simulation Region

In WEPS, the simulation region is a field (Fig. 2.2). Users must input the geometry of the simulation region. Initial conditions must also be specified for the surface and soil layers. WEPS can output soil loss/deposition over selected time intervals from the simulation region. WEPS also provides users with individual soil loss components of creep-saltation, suspension, and PM-10 size fractions. The soil loss components are particularly useful as an aid in estimating off-site impacts of wind erosion.

### Discrete Time and Space

The time step is controlled by the main program. To reduce computation time, a daily time step is used in WEPS, except for selected subroutines in the HYDROLOGY and EROSION submodels, which use hourly or subhourly time steps. Submodels are called by the MAIN program (Tatarko, 1995) in the order shown in Fig. 1. Each individual submodel controls the sequence of calculations within itself. However, in MANAGEMENT, field operations are simulated sequentially according to the order in which they appear in the management plan. Management plans usually cover at least a single year and may cover multiple years. The management plan can be initiated on any given day of the year, typically when there is no growing crop. WEPS simulates conditions and soil loss on homogeneous simulation regions. "Homogeneous" means that the soil type, biomass, and management are similar over a subregion.

### Weather Simulated from Climate Databases

WEPS requires wind speed and direction to simulate the process of soil erosion by wind. These and other weather variables are needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator

consists of the programs WINDGEN and CLIGEN (Tatarko et al., 1995).

WINDGEN simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and subdaily wind speeds when needed. A compact database (Skidmore and Tatarko, 1990, 1991) developed for WINDGEN was derived from historical monthly summaries of wind speed and wind direction contained in the Wind Energy Resource Information System (WERIS) database at the National Climatic Data Center in Asheville, North Carolina.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) erosion model (Nicks et al., 1987). It is used with WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperatures, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. CLIGEN and its database are described fully in the WEPP documentation (Nicks and Lane, 1989).

### **Field Conditions Simulated**

The HYDROLOGY submodel (Durr and Skidmore, 1995) estimates soil surface wetness; accounts for changes in soil temperature; and maintains a soil-water balance based on daily amounts of snow melt, runoff, infiltration, deep percolation, soil evaporation, and plant transpiration. Snow melt depends on maximum daily air temperature and initial snow water content. Runoff is calculated from rainfall rate greater than infiltration, adjusted for ponding and surface flow velocity. Water is infiltrated and distributed according to Darcy's Law. Potential evapotranspiration is calculated using a revised combination method of Van Bavel. Total daily potential evapotranspiration then is partitioned, based on crop leaf area index, into potential soil evaporation and plant transpiration. Hourly potential soil evaporation rates are estimated from the daily value based on soil water availability.

A soil's aggregation and surface state can dramatically affect susceptibility to wind erosion. Thus, changes in soil and surface temporal properties are simulated daily by the WEPS SOIL submodel (Hagen et al., 1995b) in response to various weather processes like wetting/drying, freeze/drying, freeze/thawing, precipitation amount and intensity, and time. Soil layer properties such as bulk density, aggregate size distribution, and dry aggregate density are maintained on a daily basis. Surface properties, such as random and oriented roughness, crust generation, coverage fraction, density, stability, and thickness, and loose erodible material on crusted surfaces also are accounted for in the SOIL submodel.

The presence of live biomass on the soil surface influences the quantity of soil that can be removed by wind erosion. Therefore, the CROP submodel (Retta and Armbrust, 1995) simulates the growth of crop plants. The crop growth model was adapted from the Erosion Productivity Calculator (EPIC) crop growth model (Williams et al., 1990), which simulates

a variety of crops and plant communities while accounting for water stresses. It calculates daily production of masses of roots, leaves, stems, and reproductive organs and also leaf and stem areas. Additional capabilities and modifications have been incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion. Some of the factors that affect wind erosion are the flexibility and arrangement of individual plant parts, distribution of plant parts by height, and number of plants per unit area (Shaw and Periera, 1982). Thus, leaves and stems are accounted for separately because: 1) stems of young seedlings are roughly 10 times more effective than leaves, on a per-unit-area basis, in depleting wind energy; 2) leaves are more sensitive to sandblast damage than are stems; and 3) decomposition rates of stems and leaves are different.

The DECOMPOSITION submodel (Steiner et al., 1995) for WEPS simulates the decrease in crop residue biomass from microbial activity. The decomposition process is modeled as a first order reaction, with temperature and moisture as driving variables. Standing residue is significantly more effective than flat residue at reducing wind energy at the soil surface. Hence, it is maintained separately from flat residue, and the conversion from standing to flat is simulated. The quantities of biomass remaining after harvest are partitioned into standing, surface, buried, and root pools with belowground biomass decomposition calculated for each soil layer. Because crop residue decomposition varies by type and changes with residue age, each pool is subdivided further into 1) the most recently harvested crop pool, 2) the penultimate crop pool, and 3) a "generic" crop pool that contains all older residue mass.

WEPS is expected to reflect the effects of various management practices upon wind erosion, and that is done by the MANAGEMENT submodel (Wagner and Ding, 1995). All major management operation classes are represented, such as primary and secondary tillage, cultivation, planting/seeding, harvesting, irrigation, fertilization, grazing, and burning. Each individual operation is simulated within the MANAGEMENT submodel as a series of physical processes. Those processes include 1) soil mass manipulation (changes in aggregate size distribution, soil porosity, mixing soil and residue by depth, and soil layer inversion); 2) surface modification (creation or destruction of ridges and/or dikes that form oriented surface roughness, changes in surface random roughness, and destruction of surface crusts); 3) biomass manipulation (burying and resurfacing residue, cutting standing residue, flattening standing residue, killing live crop biomass, and biomass removal); and 4) soil amendments (fertilization (not available in WEPS 1.0), planting, and irrigation).

### **Erosion Processes Simulated**

The EROSION submodel (Hagen, 1995) decides if erosion can occur based on the current soil surface roughness (oriented and random), flat and standing biomass, aggregate size distribution, crust and rock cover, loose erodible material on a crust, and soil surface wetness. If the maximum daily wind speed reaches 8 m/s at 10m and snow depth is less than 20mm, the surface condition is evaluated on a subhourly basis to determine if erosion can occur. The EROSION submodel simulation performs the following functions: 1) calculates

friction velocities based on the aerodynamic roughness of the surface, 2) calculates static threshold friction velocities, 3) computes soil loss/deposition within each grid cell, and 4) updates soil surface variables to reflect changes in soil surface "state" caused by erosion.

### **Summary Comparison of WEPS and WEQ**

Users of wind erosion prediction technology encounter a wide range of challenging environmental problems that require solutions. WEQ was unable to meet some of these needs. After extensive consultations with users, the WEPS structure was designed with the capabilities to meet the needs identified. As such, WEPS represents new technology and is not merely an improvement and recoding of WEQ technology. Also, WEPS contains many simplifications to maintain reasonable computation times. Because many users are familiar with WEQ, a brief comparison of WEPS and WEQ follows to facilitate understanding of WEPS modeling techniques.

WEQ predicts average erosion along line-transects across the field, whereas WEPS treats the field as two-dimensional. The WEPS EROSION submodel simulates soil loss/deposition for grid areas over the entire simulation region. This feature allows users to "look inside" by specifying arbitrary accounting regions within the simulation region and, thus, obtain results averaged over selected grid areas within the accounting region (not available in WEPS 1.0).

WEQ predicts only long-term, average, soil loss. WEPS calculates on a daily basis and allows users to specify the output intervals. Thus, users can obtain outputs ranging from single storms to multiple years. By simulating for multiple years, the probability of various levels of erosion during any period of a rotation also can be determined.

The largest contrast between the two technologies is that WEPS simulates a wide range of processes to describe field surface conditions and wind erosion, whereas WEQ depends on users to input correct estimates of the field surface conditions. Unfortunately, erosion does not vary linearly with residue cover and other temporal field conditions. Therefore, simply specifying average field conditions as inputs likely will not yield the best estimates of long-term average erosion.

The WEQ contains no feedback loop that modifies the field in response to weather or erosion. In WEPS, the driving forces of weather cause surface temporal properties of the field to change. Thus, in a year with high rainfall, the field soil roughness may be reduced below average, while above average biomass production prevents erosion. However, in a drought year, biomass and aggregate size may both be below average, but tillage ridges may then be the primary control against soil erosion.

The modeling techniques used to simulate processes in WEPS vary. The WEATHER submodel generates stochastic simulated weather variables. Mechanistic and statistical

relations are used to represent processes in the other submodels. However, a structured design methodology was used. First, the major wind erosion processes, such as emission, abrasion, and trapping were identified. Next, the individual temporal soil and biomass properties that affect the wind erosion processes were selected. Then, WEPS submodels were designed to simulate the general processes that control both the surface temporal properties and the erosion processes. Finally, parameters from the databases were used to make the simulation of various processes unique for specific soil, crop, and management actions.

### **Implementation**

The current WEPS model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The coding guidelines used, with some minor modifications for WEPS, are outlined in the "Water Erosion Prediction Project (WEPP) Fortran-77 Coding Convention" (Carey et al., 1989). The model can be run in a Windows, Unix, or Linux environment. WEPS science code and implementation is documented fully in the WEPS Technical Description (Hagen et al., 1995a).

### **WEPS Updates**

The WEPS model is continually being improved with periodic updates. The USDA-ARS Wind Erosion Research Unit (WERU) has established several means for obtaining the latest release of the WEPS model, databases, documents, and other related information as they become available.

For users with Internet access, WERU has established a World Wide Web site. The URL for WEPS downloads is: <http://weru.ksu.edu/weps>. This site contains all the information WEPS. Specific WEPS information also can be obtained through E-Mail at: [weps@weru.ksu.edu](mailto:weps@weru.ksu.edu).

Users without Internet access can obtain WEPS update information by contacting:

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## Quick Start for WEPS 1.0


WEPS is a complicated model with a potential for numerous inputs. However, for simple simulations, WEPS is easy to operate. The following quick start guide will describe how to make a simple simulation run. Double left click on the Weps1.0 icon on the computer screen 'desktop'. Note: the NRCS standard is to start WEPS from the 'Start Menu' (e.g., "Start>Programs>USDA Applications>WEPS>WEPS1.0"). The WEPS1.0 main screen will then appear.

### A Simple Simulation

For a simple simulation, only four types of information are entered on the main screen.

1. Describe the simulation field geometry.
  - a. Select the field dimensions geometry in the panel labeled "Simulation Region Information".
    - i. Type in the specific X-Length and Y-Length field dimensions.
  - b. Select field orientation in the panel labeled "Simulation Region Information".
    - i. Enter the specific field orientation ( $\pm 45^\circ$  max) relative to true north, in the "Orientation" box.
  - c. Select any barriers if present, in the panel labeled "Wind Barrier Information".
    - i. To place a barrier on the field, click the radio button  for the desired side of the field. Then select the type of barrier for that side of the field from the drop down list . Note that WEPS 1.0 only allows barriers on the field borders. The barrier properties can be viewed or edited by clicking the "Edit Selected Barrier" button at the bottom of the barrier panel. To remove a barrier click the radio button on , then select "none" from the drop down list.
2. Select a field location (for weather files).
  - a. In the panel labeled "Location Information", use the mouse to select a State and County from the drop down menus . The closest weather stations to the center of the selected county will be loaded.
3. Select a soil.
  - a. In the bottom panel of the window labeled 'Soil', use the mouse to select a soil from the drop down "Template" menu .
4. Select a management scenario.

- a. In the bottom panel of the window labeled 'MCREW', use the mouse to select a crop rotation from the drop down "Template" menu .

Once these items are complete, click the 'Run' button  on the tool bar at the top of the screen. You will then see indicators that WEPS1.0 is running. When the simulation run is finished, the "WEPS Project Summary" screen will appear. If WEPS encounters an error during a simulation run, a screen appears ('Send Email to WEPS Support') which allows you to report the error to WERU. The user will be prompted to enter an email address and a short message. If you are connected to the Internet at the time of the error, clicking 'OK' will email the report to WERU along with all files necessary to duplicate the error so that it can be addressed.

### **WEPS Project Summary**

The Project Summary for a simulation run will automatically display at the conclusion of a simulation run. To learn how to obtain more detailed output see the WEPS User Manual.

The Project Summary contains names of the input files as well as other input parameters and basic soil loss information by rotation year and the average annual for the total simulation. Soil loss output in the Project Summary includes: Gross Loss which is the average erosion within the field; Total which is the average total net loss from the field; Creep/Salt which is the average creep plus saltation net loss from the field; Suspension which is the average suspension net loss from the field; and PM10 which is the average PM10 net loss from the field.

### **Exiting WEPS 1.0**

To exit WEPS 1.0, click "Project" on the menu bar at the top of the main screen, then click "Exit". You will be asked if you want to save your project. Clicking 'Yes' will bring up a file save box. You will also be asked to confirm if you really want to exit WEPS 1.0.

### **Additional Information**

WEPS has capability for many simulation run options as well as detailed output. Consult the WEPS 1.0 User Manual for complete details. For further information regarding WEPS contact:

USDA-ARS Wind Erosion Research Unit  
1515 College Avenue  
Manhattan, Kansas 66502

Phone: 785-537-5559  
E-mail: [weps@weru.sku.edu](mailto:weps@weru.sku.edu)  
Web: <http://www.weru.ksu.edu/weps>

**SCIENCE**

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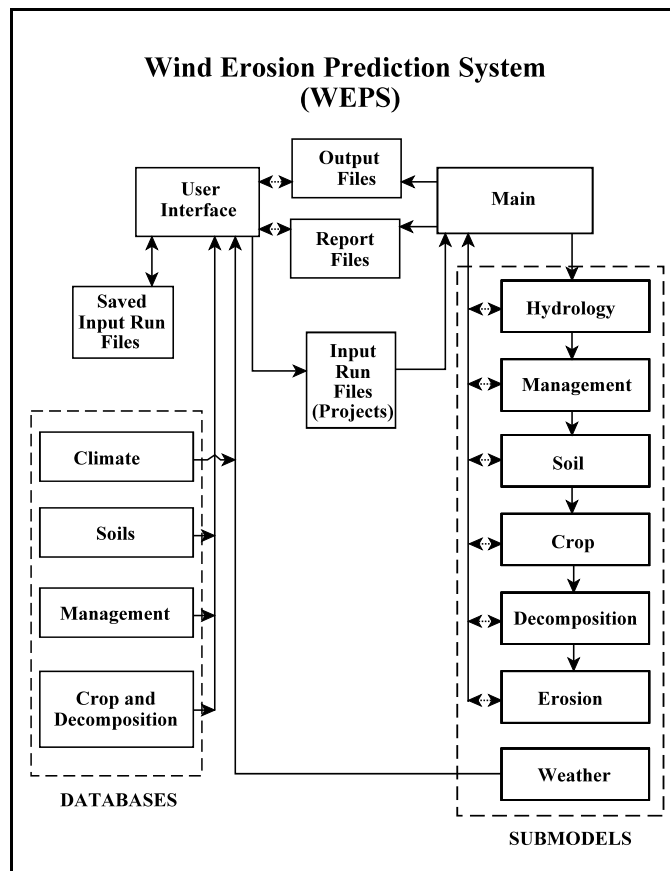
**HOW WEPS SIMULATES  
WIND EROSION**





## Interface

This section describes the WEPS 1.0 User Interface program implementation and how it interacts with the WEPS science model. The WEPS ‘science’ model refers to the computer code and executable program that performs the actual calculations of field conditions and erosion processes for a simulation run. A simple flow diagram of the WEPS science model and User Interface is shown in Figure 3.1. A detailed description of how to operate the WEPS 1.0 User Interface is described later in this document (Chapter 4, ‘How to Operate WEPS’).



**Figure 3.1.** A flow diagram of the WEPS science model and User Interface.

A simplified description of the science model is provided later in this chapter. The inputs to the science model reside in a series of ASCII input files. These input files are: a Windgen file (\*.win), a Cligen file (\*.cli), an initial field conditions file (\*.ifc), a management file (\*.man), and a run file (weps.run). The science model can be executed from the command line through the interface. When WEPS is executed, the science model reads the input files accesses necessary databases, calls each submodel daily and performs the simulation, and writes output files. The output is written to one or more ASCII files. Although building the input files by hand, executing the model on the command line, and interpreting the output files can be time consuming and confusing, the WEPS 1.0 User Interface simplifies this process.

The WEPS 1.0 User Interface is written in Java. The interface can be thought of as a ‘shell’ or ‘wrapper’ around the science model which does not affect the execution of the science model. Through the interface program, the user can easily enter the information necessary to create and edit the input files. A description of how to enter this information is given later in this document (Chapter 4, ‘How to Operate WEPS’). Once the field, location, soil, and management are described,

pressing the 'Run' button performs a series of commands to execute the science model. The interface first calls the Cligen and Windgen weather generators which create the Windgen and Cligen files for the simulation. Then the WEPS science model is called and executed as described above. When the science model is finished, the interface reads and displays the output file.



### **Main Program**

The MAIN program is the portion of the science model which controls the initialization and execution of a WEPS simulation run. It calls subroutines that read input data and outputs the general report. In addition, MAIN calls submodels on a daily basis, which update the field conditions. If the maximum wind speed for the day exceeds a set velocity great enough to cause soil movement (i.e., 8 m/s), MAIN then calls the EROSION submodel to simulate erosion processes. The current version of WEPS reads in the climate data produced by the WEATHER submodel; performs daily simulation of the hydrologic and soil conditions, crop growth, and residue decomposition; and accounts for management effects. Finally, the model determines soil erosion by wind for the desired simulation period.

### **Program Description**

The current version of MAIN requires the following files for a WEPS simulation run: a) a simulation run file which describes the field shape and barriers, simulation period, location of other input files, and types of output ; b) an initial field conditions file which describes soil conditions at the start of a simulation; d) a tillage/management file which describes the management system; and e) two climate files, one each in the CLIGEN and WINDGEN formats, that provide climate data on a daily basis.

The MAIN program begins by initializing local variables and then calls the subroutine INPUT which reads the simulation run file and the initial field conditions file. The simulation then is executed as a daily loop that controls the counters for the current day and an embedded subregion loop. The model can perform any length of simulation on a daily time step. However, WEPS performs a simulation for one rotation cycle to initialize surface conditions before simulations of wind erosion are performed. For each simulation day, the daily weather is read from the CLIGEN and WINDGEN data files. As some of the submodels are executed, summary information may be compiled for output. All submodels except EROSION are called within the subregion loop. Once field conditions are updated, if maximum wind speed for the day exceeds a set minimum (i.e., 8 m/s), the EROSION submodel then is called to determine threshold conditions and compute soil erosion. Finally, the MAIN program calls subroutine BOOKEEPING to account for field conditions and soil loss for periods throughout the rotation. CALTOT is then called, which outputs a series of user-selected output forms with general information about the simulation run.

The “WEPS Technical Description” provides a more detailed description of the science behind WEPS and is available from WERU. The current WEPS science model is coded in FORTRAN conforming to the ANSI FORTRAN 77 and Fortran 95 standard. The inputs to the science model reside in a series of ASCII input files. These input files are: a Windgen file (\*.win), a Cligen file (\*.cli), an initial field conditions file (\*.ifc), a management file (\*.man), and a run file (weps.run). The science model can be executed from the command line or the interface. When WEPS is executed, the science model reads the input files

accesses necessary databases, calls each submodel daily and performs the simulation, and writes output files. The output is written to one or more ASCII files.

## **Weather Submodel**

### **Introduction**

The Wind Erosion Prediction System (WEPS) requires wind speed and direction in order to simulate the process of soil erosion by wind. These and other weather variables are also needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator of WEPS consists of the separate programs WINDGEN and CLIGEN and simulates the needed weather variables on a daily basis and wind speed on an hourly basis.

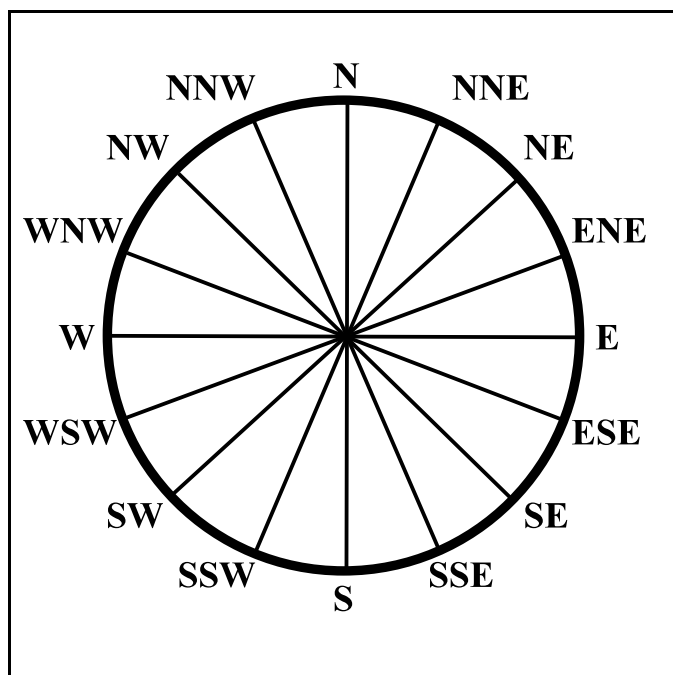
WINDGEN is the program that simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and subdaily (e.g., hourly) wind speed on a daily basis.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) family of erosion models (Nicks et al., 1987). It is used by WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperature, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. Those interested in CLIGEN and how it simulates these variables should consult the WEPP documentation (Nicks and Lane, 1989). Both CLIGEN and WINDGEN are executed together under the WEPS 1.0 user interface.

### **Wind Simulation**

Prediction of wind speed and direction, like most meteorological variables, is extremely difficult. Even with advanced technology, such as sophisticated numerical models and super computers, using climatological means is only as accurate as predicting meteorological variables a few days in advance (Tribbia and Anthes, 1987). Therefore, we resort to historical statistical information about most meteorological variables and use stochastic techniques to determine likelihood of various levels of those variables. We developed a stochastic wind simulator to furnish wind direction and wind speed as needed by the Wind Erosion Prediction System described by Hagen (1991).

Although the development of the WINDGEN database and wind generator is described by Skidmore and Tatarko (1990, 1991), we give here some of the details. Our database was created from historical monthly summaries of wind speed and wind direction. Two-parameter Weibull (Takle and Brown, 1978; Corotis et al., 1978) curves were fit to the monthly summary direction and speed distribution data. Historical wind data requires a detailed station history and a sufficient period of record (5 years minimum) to be suitable for wind simulation in WEPS. Therefore the coverage of historical wind stations is sparse in some areas of the United States.



**Figure 3.2.** The sixteen cardinal directions used for wind direction in WEPS.

WINDGEN first determines the wind direction for the day based upon a random number selected between 0 and 1. Since the wind direction distribution in the WINDGEN database specifies the fraction of the time the wind comes from each of the 16 cardinal directions (Fig. 3.2) for each month, a cumulative frequency distribution curve is created and scaled to range from 0 to 1. Thus, the random number selected determines the wind direction for that day.

WINDGEN then determines the 24 hourly wind speeds for the day. That is done by selecting 24 random numbers between 0 and 1. These random numbers are then compared to the scaled monthly

cumulative wind speed distribution for this day's direction to obtain the 24 hourly wind speeds for that day. The generator performs a few additional steps to ensure that it doesn't over or under estimate the long-term average wind speed (energy) that the summarized historical wind data reflects and to group higher hourly wind speeds together in the same day rather than just randomly distributing them across several days. It also ensures that "calm" hours (hourly wind speeds less than 1 m/s) are accurately reflected in the generated wind data series.

After the 24 hourly wind speeds have been selected, WINDGEN then determines the maximum hourly wind speed for the day and sets it to the "hour of maximum wind speed" available in the database for the current month. It then distributes the 24 hourly wind speeds such that the next two highest hourly wind speeds are adjacent to the highest hourly wind speed, the next two highest are then set adjacent to the previous two, etc. Thus, WINDGEN attempts to "build" a daily wind speed distribution which mimics the daily cycle of the wind speed increasing during the day until the "hour of maximum wind speed", and then decreasing after that hour again.

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### Hydrology Submodel

The HYDROLOGY submodel of the Wind Erosion Prediction System (WEPS) uses inputs generated by other WEPS submodels such as WEATHER, CROP, SOIL, MANAGEMENT, and DECOMPOSITION to predict the water content in the various layers of the soil profile and at the soil-atmosphere interface throughout the simulation period. Accurate simulation by the other WEPS submodels requires prediction of the daily changes in soil water profiles. However, estimating soil wetness at the soil-atmosphere interface is emphasized, because it significantly influences the susceptibility of the soil to wind erosion.

The HYDROLOGY submodel of WEPS maintains a continuous, daily, soil water balance using the equation:

$$SWC = SWCI + (PRCP + DIRG) + SNOW - RUNOFF - ETA - DPRC \quad (3.1)$$

where SWC is the amount of water on the soil profile in any given day (mm), SWCI is the initial amount of water in the soil profile (mm), PRCP is the amount of daily precipitation (mm), DIRG is the amount of daily irrigation (mm), SNOW is the daily snow melt minus daily snow accumulation (mm), RUNOFF is the amount of daily surface runoff (mm), ETA is the amount of daily actual evapotranspiration (mm), and DPRC is the amount of daily deep percolation (mm).

The amount of daily precipitation (PRCP) is partitioned between rainfall and snowfall on the basis of the average daily air temperature. If the average daily temperature is 0°C or below, the precipitation takes the form of snowfall; otherwise, it takes the form of rainfall.

The snow term (SNOW) can be either positive, equaling the daily snow melt, or negative, equaling the daily snow accumulation. The melted snow is treated as rainfall and added to the precipitation term in Equation 3.1 when accounting for daily runoff and infiltration. On the other hand, the accumulated snow is subtracted from the daily precipitation during the estimation of the daily soil water balance with Equation 3.1.

Simulation of soil-water dynamics on a daily basis by the HYDROLOGY submodel involves three major sequences. First, the submodel partitions the total amount of water available from precipitation, irrigation, and/or snow melt into surface runoff and infiltration. The submodel stores the daily amount of water available for infiltration into the soil profile. Second, the submodel determines the influence of ambient climatic conditions by calculating the potential evapotranspiration. Third, the submodel redistributes soil water in the soil profile on an hourly basis, which provides hourly estimations of water content in the soil profile. The submodel estimates the actual rate of evapotranspiration by adjusting the potential rate on the basis of soil water availability. Deep percolation from the soil profile is estimated to be equal to the conductivity of the lowermost simulation layer, assuming a

unit hydraulic gradient.

The HYDROLOGY submodel estimates surface runoff and infiltration for each simulation day that has precipitation and/or irrigation. The submodel estimates the daily amount of water available for infiltration into the soil by subtracting the amount of daily surface runoff from the amount of daily precipitation, snow melt, and/or irrigation. The infiltration water is stored in the uppermost simulation layer, until its water content reaches field capacity. Any excess water then is added to the succeeding lower layer, where it is stored with the same maximum storage restriction. This is repeated until complete water storage is obtained. Any excess water that flows out from the lowermost simulation layer becomes a part of a deep percolation.

Potential evapotranspiration is calculated using a revised version of Penman's combination method (Van Bavel, 1966). The total daily rate of potential evapotranspiration then is partitioned on the basis of the plant leaf area index into potential soil evaporation and potential plant transpiration. The potential rate of soil evaporation is adjusted to account for the effect of plant residues in the simulation region. Furthermore, the daily potential rates of soil evaporation and plant transpiration are adjusted to actual rates on the basis of water availability in the soil profile.

The HYDROLOGY submodel uses a simplified forward finite-difference technique to redistribute soil water with the one-dimensional Darcy equation for water flow. The time step of the soil water redistribution is 1 hour, which allows for an hourly estimation of soil wetness as needed for WEPS. Knowledge of the relationship between unsaturated hydraulic conductivity and soil water content is required for solving the governing transport equations of water movement through the soil. The submodel uses Campbell's (1974) method to calculate the unsaturated hydraulic conductivity of the soil from the more readily available soil water characteristic curve and saturated hydraulic conductivity data. Because water release curve data of the soil are not always available, the submodel provides alternative options to estimate the hydraulic parameters of the water release curve that are needed as inputs to run the soil water redistribution segment of the submodel.

The HYDROLOGY submodel predicts on an hourly basis soil wetness at the soil-atmosphere interface by using a combination of two techniques. The submodel extrapolates water content to the soil surface from the three uppermost simulation layers. A numerical solution known as Cramer's rule (Miller, 1982) is used to obtain an estimate of the extrapolated water content at the soil surface by solving the three simultaneous equations that describe the relationship between water content and soil depth for the three uppermost simulation layers. The submodel also interpolates the functional relationship between surface-soil wetness and the hourly evaporation ratio.



**References**

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## Management Submodel

### Introduction

WEPS is expected to reflect effects of various management practices upon wind erosion. The diversity of current practices applied to cropland by land managers makes this a daunting task. However, WEPS must adequately simulate typical cultural practices to accurately assess their affects upon wind erosion control. The MANAGEMENT submodel is assigned the task of handling the cultural practices applied by land managers which affect the soil/surface "state" within WEPS.

### Purpose

All cultural practices applied by land managers are by definition "human initiated". These human-controlled processes affecting the soil and field surface "state" are initiated by typical management practices such as tillage operations, planting, harvesting, irrigation, etc. Therefore, the purpose of the MANAGEMENT submodel is to model what are considered the *major* human-controllable actions that can affect the "system state" within WEPS, in particular the system state variables defining the temporal soil and surface conditions.

### Objectives

The MANAGEMENT submodel objectives are:

1. To model the primary human-initiated processes that can affect a site's susceptibility to wind erosion.
2. To provide the framework necessary to process a list of specified human-initiated actions, i.e., the cultural practices applied to a field such as a tillage/crop rotation sequence.

Keeping with the WEPS philosophy, The MANAGEMENT submodel simulates processes via a physical basis if possible, incorporates the conservation of mass and energy concepts, and uses a minimum number of parameters with readily available and/or attainable values.

### Assumptions and Limitations

Several assumptions and limitations have been imposed on the MANAGEMENT submodel. The reasons vary from simply limiting the scope of the submodel, to inadequate knowledge of specific processes that may have a significant impact on the soil and/or surface. Here is the list of current assumptions and limitations, provided in no particular order, that impact the MANAGEMENT submodel.

1. Total soil water content within the current tillage zone is assumed to be unaffected by a tillage operation. The HYDROLOGY submodel is expected to handle changes in surface water content and therefore appropriately represent the usual rapid drying of the surface layer following tillage.

2. Tillage speed is not included as an independent variable affecting how a tillage operation modifies the soil and surface. A "typical" tillage speed is assumed for each tillage operation upon which the affects upon the soil and surface are based. Future versions of the MANAGEMENT submodel may incorporate tillage speed if sufficient data becomes available to model its effects upon the soil and surface.
3. Tillage depth is assumed to not influence how a tillage operation affects the soil and surface except for determining which soil layers are directly affected by a tillage operation. Again, the MANAGEMENT submodel may be extended to incorporate tillage depth effects if sufficient data becomes available in the future.
4. Effects of tillage operations on soil layers below the tillage depth are not considered, i.e., subsoil compaction below the tillage zone due to tillage. This will be addressed in a future release of the MANAGEMENT submodel.
5. Effects of a management operation are assumed homogeneous within a subregion. Effects due to tractor tires will not be considered. Certain zone-related tillage operations, such as row cultivator, will be treated in a manner such that the result will be "averaged" or "equivalent" values which represent the homogeneous region.
6. Emergency tillage, for wind erosion prevention or control, and strip cropping practices is considered in WEPS by specifying multiple separate, non-contiguous homogeneous subregions.
7. Ridge and dike geometric specifications (oriented roughness) will be provided by the user. If the tillage depth specified is not sufficient to create or destroy them (for a particular tillage operation that does so), the MANAGEMENT submodel will modify the tillage depth accordingly to obtain the desired ridge and/or dike specifications. Tillage operations that do not modify the current ridge and/or dike specifications will not do so (i.e., ridge tillage equipment).
8. Soil tillage depths will be adjusted to the nearest soil layer boundary. This will ensure that the most recent tillage operation modifications on the soil "state" are adequately represented. In the future, soil layer boundaries may be adjusted appropriately to accommodate tillage depths that would split a soil layer, i.e., a new layer boundary would be created at the prescribed tillage depth.
9. Aggregate stability and aggregate density are assumed to be unaffected by tillage operations. This decision is based on limited field data analysis. Future research may provide statistically significant affects that could then be modeled. These properties may still change among soil layers within the tillage zone due to aggregate mixing among layers caused by tillage operations.

**Submodel Description**

The approach taken within the MANAGEMENT submodel to deal with the variety of land management actions was to:

1. Identify the primary physical processes involved.
2. Represent individual management operations as a sequence of those primary physical processes.
3. Develop a MANAGEMENT file format allowing the input of user-specified sequences of management operations, i.e., a management practices/crop rotation file.

All operations modeled within the MANAGEMENT submodel fall within the following defined management categories as listed in Table 3.1.

**Table 3.1.** Management operation classes.

Operation Class	Description
Primary tillage	Tillage performed to primarily reduce surface residue, increase short-term infiltration rates, loosen subsoil hardpans, and control weed growth. Usually after-harvest tillage operations fall in this category.
Secondary tillage	Tillage typically performed in preparation for seeding or planting operations. Usually these operations are intended to smooth the soil surface, reduce the average aggregate size, and control weed growth if present.
Cultivation	Tillage specifically designed to eliminate weed growth after crop germination.
Planting/Seeding	Operations required to plant or seed a crop into a field.
Harvesting	Operation to remove biomass from a field. Biomass removed may be grain, root material, or the entire above ground biomass.
Irrigation	The artificial application or addition of water to the soil.
Fertilization	The application or addition of specific nutrients to a soil.
Burning	The removal of surface biomass with fire.
Grazing	The removal of surface biomass via livestock.

When a management or tillage operation is performed, it is simulated through a group of individual physical processes that represent the total effects of that operation. The basic individual physical processes to be modeled within the MANAGEMENT submodel of

WEPS have been grouped according to the target of their actions and outlined in Table 3.2.

**Table 3.2.** MANAGEMENT submodel processes.

Action	Process	Description
Soil Mass Manipulation	Crush	The application of forces to the soil to modify the soil aggregate structure by breaking down soil aggregates.
	Loosen/Compact	The process of decreasing soil bulk density and increasing porosity (incorporation of air) or the inverse process of increasing soil bulk density by removing air from the soil.
	Mix	The process of uniting or blending of soil layer properties, including biomass.
	Invert	The reversing of the vertical order of occurrence of soil layers within the current specified tillage zone.
Surface Manipulation	Ridge/Dike	The process of creating or destroying ridges and/or dikes (oriented surface roughness).
	Roughen	The process of modifying the random surface roughness.
	Crust	The process of modifying the soil surface crust characteristics.
Biomass Manipulation	Bury/Lift	The process of moving above ground biomass into the soil or the inverse process of bringing buried biomass to the surface.
	Cut	The process of cutting standing biomass to a prescribed height.
	Drop	The process of moving a portion of the standing biomass to the soil surface.
	Kill	The death of live biomass.
	Remove	The removal of biomass from the system (harvest, grazing, and burning).
Soil Amendments	Fertilize	Addition of nutrients to the soil.
	Plant	Addition of seeds/plants to the soil.
	Irrigate	Addition of water to the soil.

The underlying philosophy behind the MANAGEMENT submodel was to attempt to develop physical law based representations, if possible, for each of the chosen physical processes.

These processes are assumed to be independent with respect to each other and are to be simulated sequentially, even though many of them occur simultaneously in the real world. The order they are initiated in the submodel is dependent upon the specific operation.

The list of management operations performed for a given management plan (crop rotation or cyclical management practices) on a homogeneous region (subregion) is specified in a MANAGEMENT input file. The MANAGEMENT submodel checks on a daily basis for any operations to be performed on that day. If operations are needed, the MANAGEMENT submodel will execute the specified routines required to simulate the effects of those operations as instructed in the MANAGEMENT input file. When the last operation is performed for that particular crop rotation cycle, the same sequence will be repeated for the next year(s) of simulation.

A single MANAGEMENT input file may include multiple management operation lists, one for each subregion being simulated.





## Crop Submodel

### Introduction

The primary purpose of the WEPS plant growth submodel (CROP) is to obtain realistic estimates of plant growth so that the influence of vegetative cover on soil loss by wind erosion can be properly evaluated. The CROP submodel (Retta and Armbrust, 1995), was adapted from the Erosion Productivity Impact Calculator (EPIC) crop growth model (Williams, et.al, 1990). Additional capabilities and modifications have been developed and incorporated into the CROP submodel to meet the need for predicting effects of a growing crop on wind erosion. Young seedlings provide some protection from wind erosion. However, not all plant parts are equally effective. Stems of young plants, on a per-unit area basis, are roughly 10 times more effective than leaves in depleting wind energy. Other differences between leaves and stems are that, leaves are more sensitive to sandblast damage than are stems; and leaf and stem residues decompose at different rates. To properly account for these differences the CROP submodel gives daily estimates of leaf and stem growth in mass and area. At harvest, the 'grain' is removed and the 'straw' may consist of leaves, stems, and 'chaff'. In most case the leaf and 'chaff' residue is short-lived and only the stem residue may provide protection on a longer-term basis. The CROP submodel gives estimates of the amount of leaf, stem, 'grain', and 'chaff' mass produced on a daily basis. An important consideration is the effect of plant density on the amount of cover provided by growing seedlings during the early vegetative growth period. Many management practices leave the soil vulnerable to the forces of wind erosion prior to seeding until the growing plants develop sufficient cover. During the period from emergence to the development of adequate cover, the amount of cover is directly proportional to the number of seedlings per unit area. The higher the number of plants per unit area the greater the cover provided by the growing vegetation. To account for the differences in cover due to initial plant density, the leaf and stem area indexes at emergence (which are used by the EROSION submodel in computations of soil loss) are calculated by multiplying the initial areas per plant by the number of seedlings per unit area. Thus the greater the number of seedlings per unit area at emergence, the greater the protection provided by the young seedlings from wind erosion. The CROP submodel uses data inputs of plant, weather, hydrology, and management to estimate leaf mass, stem mass, reproductive mass, yield mass, 'chaff' mass, and root mass of 'live' plants (crops) on a daily basis. Other plant characteristics estimated daily are: root mass by soil layer, rooting depth, plant height, and canopy cover.

### Phenological development

Phenological development of the crop is based on growing-degree-day (GDD) accumulation. The crop parameter file for CROP contains, for each crop, the potential GDDs from planting to physiological maturity and the relative GDDs from planting to emergence, to the start of the reproductive phase, and to the start of leaf senescence. CROP uses the same procedures as EPIC for simulating annual or perennial plants, and winter or summer crops. Annual plants 'grow' from planting to the date when the accumulated GDDs equal the potential

GDDs for the crop. For annual winter crops, such as wheat, GDD accumulation (therefore growth) does not occur during the period of dormancy. Perennial crops maintain their root systems throughout the year, although the plant may become dormant after a frost. After the end of dormancy, plants start growing when the average daily air temperature exceeds the base temperature of the plant.

### **Emergence**

Emergence occurs when the GDD accumulation from date of planting equals 6% of the seasonal GDD. CROP does not account for effects of soil temperature, soil water, soil crusting, soil strength, seeding depth, soil removal or deposition caused by wind erosion, which can influence germination, seedling emergence, survival, and growth.

### **Biomass Production**

Shortwave radiation at the top of the canopy is multiplied by the factor C to estimate the amount of photosynthetically active radiation (PAR). The amount of PAR intercepted which is calculated using Beer's Law, is multiplied by a biomass efficiency factor to obtain net daily dry biomass production.

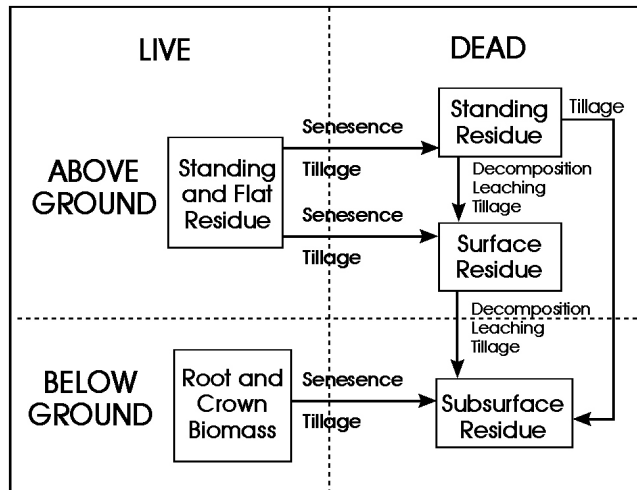
### **Growth Constraints**

Potential growth and yield seldom are achieved, because of stress caused by suboptimal conditions. The CROP submodel adjusts daily biomass and area growth for water, temperature, and nutrient stresses. Water, temperature, and nutrient stress factors range from 0, where no growth will occur, to 1 for no limitation in growth. For any simulation day, the minimum value of the water, nutrient, or temperature stress factor adjusts daily produced biomass.

### **References**

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### Residue Decomposition Submodel



**Figure 3.3.** Biomass distribution and transfer between residue pools.

#### Model Overview

The DECOMPOSITION submodel simulates the decrease in crop residue biomass due to microbial activity. The decomposition process is modeled as a first order reaction with temperature and moisture as driving variables. The total quantities of biomass remaining after harvest are partitioned between standing, surface, buried, and root pools. Below ground biomass decomposition is calculated for each soil layer. Figure 3.3 depicts the distribution of biomass between residue pools.

Since residue decomposition can require a long period of time, crop residue biomass from sequential harvests are accounted for in separate data pools using an indexing variable (IAGE). Standing, surface, buried, and root biomass from the most recently harvested crop will be indexed IAGE = 1, biomass from the penultimate crop IAGE = 2, and for surface biomass a third pool will be accounted for as IAGE = 3. On a day of harvest, any biomass remaining from a previous crop is moved into the older age pools and residue from the current crop are indexed IAGE = 1. Decomposition rates for biomass pools one and two will be appropriate for the specific crops while biomass pool three will have a decomposition rate that reflects a slow rate of decomposition.

#### Decomposition

The general decomposition equation is a simple first order rate loss equation:

$$M_t = M_o * \exp^{-k \text{CUMDD}} \quad (3.2)$$

where  $M_t$  is the present quantity of biomass ( $\text{kg m}^{-2}$ ) in the standing, surface, buried, or root pools;  $M_o$  is the initial biomass ( $\text{kg m}^{-2}$ );  $k$  is a crop specific rate constant used to calculate residue biomass changes ( $\text{day}^{-1}$ ); and CUMDD is a weighted-time variable calculated from functions of temperature and moisture. Optimum moisture and temperature conditions result in the accumulation of 1 decomposition day for each day of the simulation. When moisture or temperature limit the rate of decomposition, the minimum of the moisture or temperature functions is used to accumulate a fraction of a decomposition day.

Residual moisture in the residues is considered to decrease by 60 % each day following the wetting event. Both precipitation and soil moisture influence the moisture of surface residues.

### **Changes in Standing Residue Biomass and Population**

Standing residue losses occur from both microbial and physical actions. Physical transfers of crop residues from the standing biomass pool will reduce both the population size and biomass. When the changes occur due to physical forces such as wind, snow, gravity, or wheel traffic the transfer is to the surface pool. Tillage may result in redistribution to both the surface and buried pools. A daily estimate of the standing population is required in order to evaluate stem area index (SAI) and its influence on aerodynamic resistance (Steiner et al, 1994). The equation used to predict residue cover from flat residue is from Gregory (1982).

### **Modifying Variables Due to Tillage Operations**

On a day of tillage, the distribution of residues will change between standing, flat and buried components depending on the tillage implement being used. The MANAGEMENT submodel will need to update the current biomass for each position (standing, surface, buried, and root) in each of the three age pools (1, 2, 3). Soil surface cover is then updated from the amount of biomass remaining in the surface and standing pools.

### **Crop Residue Decomposition Submodel Summary**

1. Initialize decomposition variables for standing, surface, buried, and root biomass. Initialize decomposition rate constants for old residues.
2. At harvest:
  - a. Transfer residue biomass, stem numbers, decomposition days, decomposition rates and cover factors from younger to older age pools.
  - b. Check MANAGEMENT to see if the harvest process buried residues.
  - c. Put mass and stem information for harvested crop into IAGE = 1 pools.
  - d. Initialize decomposition rates and cover factor variables for harvested crop.
3. Daily:
  - a. Test for harvest or tillage date.
  - b. Calculate temperature and moisture functions and accumulate decomposition days.

- c. Calculate change in biomass for residue pools
  - standing residue mass
  - surface residue mass
  - below ground residue mass
  - root residue mass
- d. Calculate transfer of standing residue mass to surface residue mass and update standing and surface biomass.
- e. Compute vertical and horizontal residue cover.

**References**

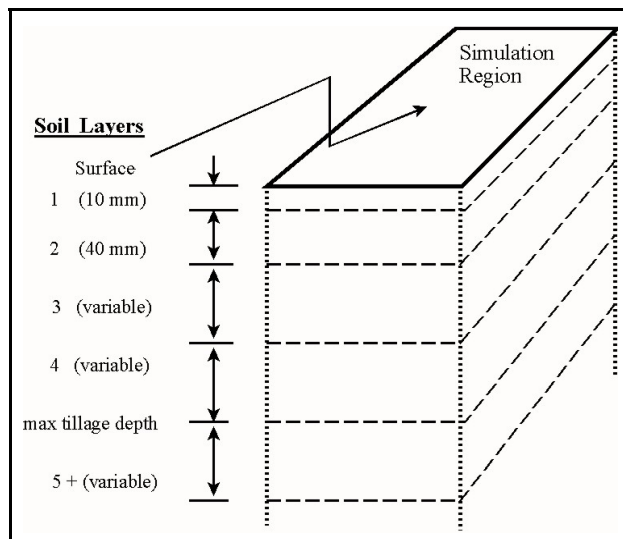
- Gregory, J. M. 1982. Soil cover prediction with various amounts and types of residue. Trans. ASAE. 28:98-101, 105.
- Steiner, J. L., H. H. Schomberg, C. L. Douglas, Jr., and A. L. Black. 1994. Standing stem persistence in no-tillage small-grain fields. Agron. J. 86:76-81.



## Soil Submodel

### Introduction

All the soil properties that control soil wind erodibility vary with time. Hence, the objective of the soil submodel is to simulate these temporal soil properties on a daily basis in response to various driving processes. On days when wind erosion or management activities occur, the Erosion and Management submodels may also update some of the same temporal variables. The driving processes that change soil temporal properties are mostly weather related, and hence, the sequence of occurrence of individual driving processes is highly variable. Thus, the submodel must be able to update the soil variables given an arbitrary driving process and the soil conditions for the prior day. The purpose of this paper is to provide a brief overview of the major processes that are simulated, and the temporal variables that are updated by the soil submodel. For an in-depth discussion of the equations used in the Soil submodel, see the Soil Submodel Technical Document (Hagen et al., 1995).



**Figure 3.4.** Diagram representing the spatial domain of the Soil submodel.

### Spatial Regime

In the Soil submodel, the spatial regime is considered to be uniform in the horizontal direction over the simulation region, but non-uniform in the vertical direction (Fig. 3.4). Hence, the vertical direction is divided into layers in each soil profile. Some of the layer boundaries are selected to coincide with the layers determined by the NRCS Soil Survey of each soil. Layers one and two are initially set at 10 and 40 mm (0.39 and 1.57 inches), respectively, to allow simulation of sharp gradients in temporal soil properties near the surface.

### Soil Layering Scheme

The hydrology and crop sub-models of WEPS depend upon the soil being stratified by layers. Hydrology moves water up and down within the soil based upon the relative wetness of adjacent layers. Crop estimates plant growth based upon several factors, one of the most important being availability of water within the root zone. It is important that WEPS keep track of now how much water is available at various soil depths. Hence, WEPS views the soil as a series of layers, each layer possibly having distinct physical characteristics but this is not necessary.

WEPS divides the soil into layers based upon National Soil Information System (NASIS)

input data. The layering scheme respects the underlying NASIS data. That is, no NASIS layers are combined when creating WEPS layers. Much of the complexity of the layering process is due to the creation of the very thin top layers. The design criteria are:

10. Preserve NASIS layering, i.e. a WEPS layer cannot cross a NASIS layer boundary.
11. Try to get the first three layers to be 10, 40 and 50 mm.
12. Preserve the relative sizes, 1:4:5:5, of the top layers if the absolute size cannot be attained.
13. Divide the remaining layers into relatively uniform thicknesses, somewhat thinner at the top and thicker as depth increases.

#### **Processes Simulated and Variables Updated**

The processes simulated and the variables updated are summarized in Table 3.3. The effect of the processes on roughness is always to reduce the roughness. In contrast, many of the other variables either increase or decrease in value depending upon the prior-day value, soil intrinsic properties and the driving process. To simulate the dry stability and aggregate size distribution, for a wide range of soils, these variables were first normalized using mean and standard deviation of the variables for each soil series to give a range from 0 to 1 for each variable. The driving processes were then applied to the normalized ranges to determine the change in the normalized variable. Finally, the updated normalized values were converted to the real values of these variables.



**Table 3.3.** Soil submodel variable and process matrix.

	Surface Processes			Layer Processes		
Soil Temporal Variables	Rain	Sprinkler Irrigation	Snow Melt	Wet/dry	Freeze/thaw	Freeze/dry
<b>Roughness:</b>						
Ridge Height	X	X	X			
Dike Height	X	X	X			
Random	X	X	X			
<b>Crust:</b>						
Depth	X	X	X			
Cover fraction	X	X	X			
Density	X	X	X			
Stability	X	X	X	X	X	X
Loose mass	X	X	X			
Loose cover	X	X	X			
<b>Aggregates:</b>						
Size distribution	X	X	X	X	X	X
Dry stability	X	X	X	X	X	X
Density	X	X	X	X	X	X
<b>Layers:</b>						
Bulk density	X	X	X			

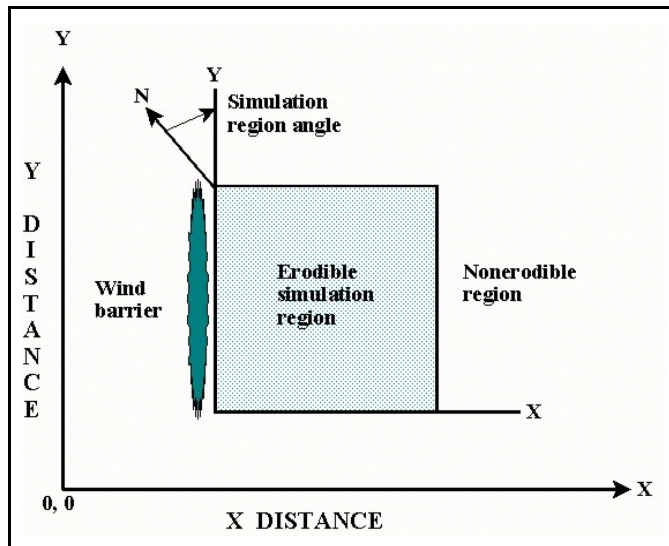
In summary, the Soil submodel outputs updated values on a daily basis for each of the variable listed in Table 1 in response to the occurrence of the various driving processes.

## References

Hagen, L.J., T.M. Zobeck, E.L. Skidmore, and I. Elminyaw. 1995b. WEPS technical documentation: soil submodel. SWCS WEPP/WEPS Symposium. Ankeny, IA



### Erosion Submodel



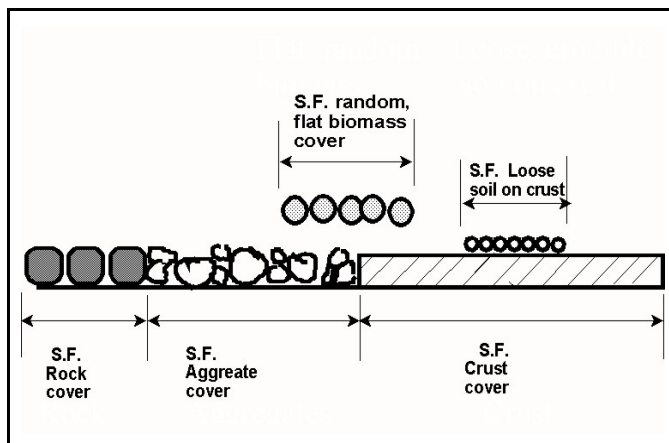
**Figure 3.5.** Schematic of simulation region geometry. Field orientation, end points of barriers, and opposite corners of the rectangular simulation region are input to the Erosion submodel.

individual grid cells representing the field. The soil/loss deposition is divided into components of saltation/creep and suspension, because each has different transport modes, as well as off-site impacts. Finally, the field surface is periodically updated to simulate the changes caused by erosion. The purpose of this paper is to provide users with a brief overview of the submodel. For an in-depth description of the equations used in this

### Introduction

The objective of the erosion submodel is to simulate the components of soil loss/deposition over a rectangular field in response to wind speed, wind direction, field orientation, and surface conditions on a sub-hourly basis (Fig. 3.5). In WEPS 1.0 barriers may be placed on any or all field boundaries. When barriers are present, the wind speed is reduced in the sheltered area on both the upwind and downwind sides of the barriers. The submodel determines the threshold friction velocity at which erosion can begin for each surface condition. When wind speeds exceed the threshold, the submodel calculates the loss/deposition over a series of

submodel, see the WEPS Erosion Submodel Technical Description (Hagen, 1995).



**Figure 3.6.** Diagram illustrating components of flat surface cover inputs to the Erosion submodel.

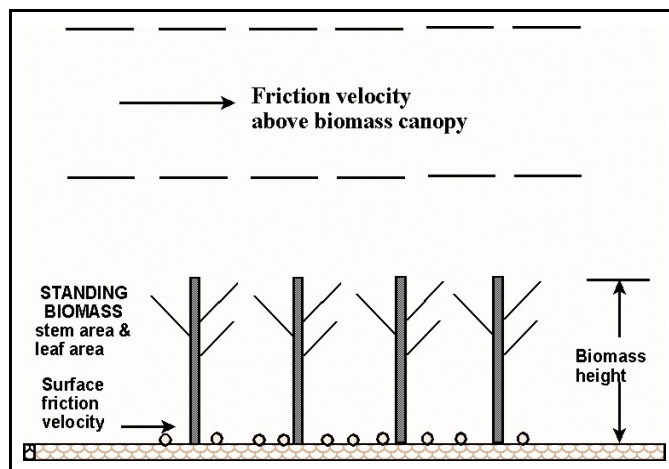
### Surface Conditions Needed as Inputs

Surface roughness is represented by both random roughness and oriented roughness. The parameters used are standard deviation of the surface heights for random roughness and the height and spacing of ridges for oriented roughness.

Surface cover is represented on three

levels (Fig. 3.6). In the first level, surface rock, aggregates and crust comprise 100 percent of the cover. In the second level, the parameter is the fraction of the crusted surface covered with loose, erodible soil. When there is no crust, this parameter is always zero. In the third level, the parameter is the fraction of total surface covered by flat, random biomass.

The aggregate density and size distribution are input parameters that indicate soil mobility. The dry mechanical stability of the clods/crust are input parameters that indicate their resistance to abrasion from impacts by eroding soil. Surface soil wetness is also input and used to increase the threshold friction velocity at which erosion begins.

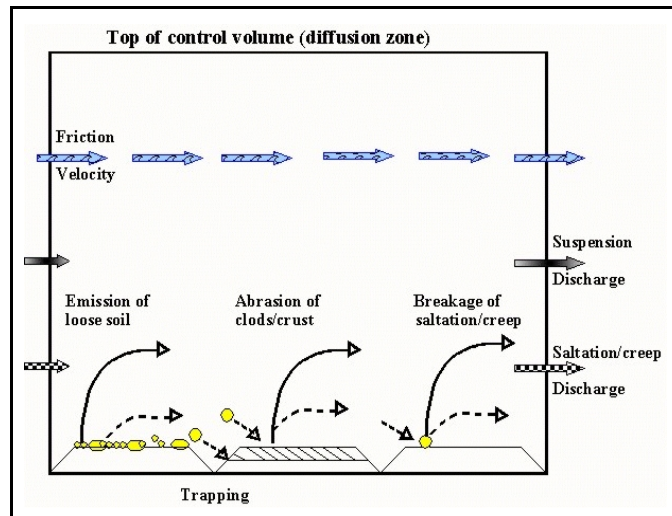


Uniformly distributed, standing biomass is 5 to 10 times more effective in controlling wind erosion than flat biomass, and thus, is treated separately. The wind friction velocity above standing biomass is depleted by the leaves and stems to obtain the surface friction velocity at the surface that is used to drive erosion (Fig. 3.7). Leaves are represented by a leaf area index and stems by a stem silhouette area index in the input parameters.

**Figure 3.7.** Diagram illustrating friction velocity above standing biomass that is reduced by drag of stems and leaves to the surface friction velocity below the standing biomass.

### Erosion Processes Simulated

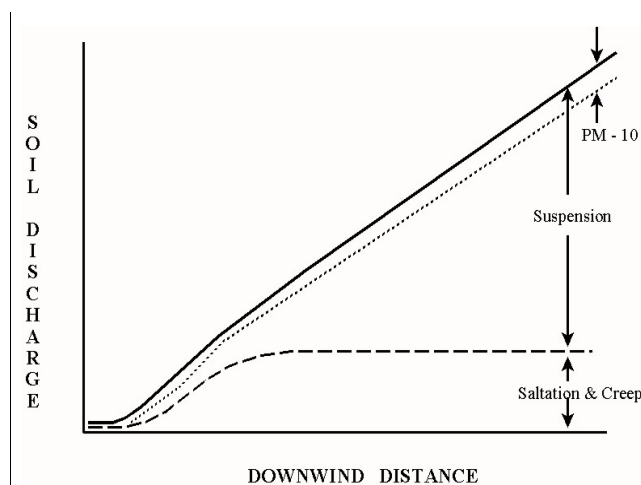
Soil transport during wind erosion occurs in three modes: creep-size aggregates, 0.84-2.0 mm (0.033 - 0.079 in.) in diameter roll along the surface, saltation-size aggregates, 0.10 - 0.84 mm (0.004 - 0.033 in.) in diameter hop over the surface, and suspension-size aggregates, < 0.01 mm (0.004 in.) in diameter move above the surface in the turbulent flow. Obviously, variations in friction velocity, aggregate density and sediment load may change the mass of aggregates moving in a given mode. Saltation and creep are simulated together, because they have a limited transport capacity that depends mainly upon friction velocity and surface roughness. The suspension component is simulated with no upper limit on its transport capacity at the field scale. A portion of the suspension component also is simulated as PM-10, i.e., particulate matter less than 10 micrometers (0.0004 in.) in diameter that is regulated as a health hazard.



**Figure 3.8.** Diagram illustrating processes simulated by the Erosion submodel on a bare soil surface in an individual grid cell.

Multiple, physical erosion processes are simulated in the erosion submodel, and these are illustrated for a single grid cell in Fig. 3.8. The two sources of eroding soil are emission of loose soil and entrainment of soil abraded from clods and crust. These sources are apportioned between saltation/creep and suspension components based on the process and soil characteristics. Three processes deplete the amount of moving saltation/creep. These include trapping in surface depressions, interception by plant stems/leaves, and breakage of saltation/creep to suspension-size.

Simulation of surface rearrangement is accomplished by allowing emissions to deplete the loose soil and armor the surface in the upwind field area. In contrast, processes such as abrasion of the protruding aggregates and trapping in depressions dominate in downwind areas and lead to smoothing the surface and a build-up of loose saltation/creep. A build-up of saltation/creep often occurs, because the transport capacity may be satisfied, but abrasion of clods/crust continues to create additional saltation/creep-size soil.



**Figure 3.9.** Diagram illustrating downwind transport capacity for saltation & creep, but a continuing increase in transported mass of suspension-size soil downwind.

Typical behavior of the downwind soil discharge simulated along a line transect for the saltation/creep and suspension components is illustrated in Fig. 3.9. The suspension component keeps increasing with downwind distance even though saltation/creep reaches transport capacity. This is because the sources for suspension-size soil are usually active over the entire field. These sources include emissions from impacts on loose soil, abrasion from clods/crust, and breakage from impacting

saltation/creep-size aggregates. Moreover, the suspension component has a transport capacity many times larger than that of saltation/creep, so on large fields it is the 'freightliner' for moving soil and saltation/creep is merely the 'pickup truck'.

### **Outputs**

The Erosion submodel calculates total, suspension, and PM-10 soil loss/deposition at each grid cell in the field. The grid cell data are summarized in other parts of WEPS and reported to users as averages over the field for selected periods. The submodel also calculates the components of soil discharge crossing each field boundary. These are reported to users based on the size ranges of aggregates as saltation/creep, suspension, and PM-10. These latter outputs are useful for evaluating off-site impacts in any given direction from the eroding field.

### **References**

Hagen, L.J. 1995. Wind Erosion Prediction System (WEPS) Technical Description: Erosion submodel. IN Proc. of the WEPP/WEPS Symposium. Soil and Water Conserv. Soc., Des Moines, IA.

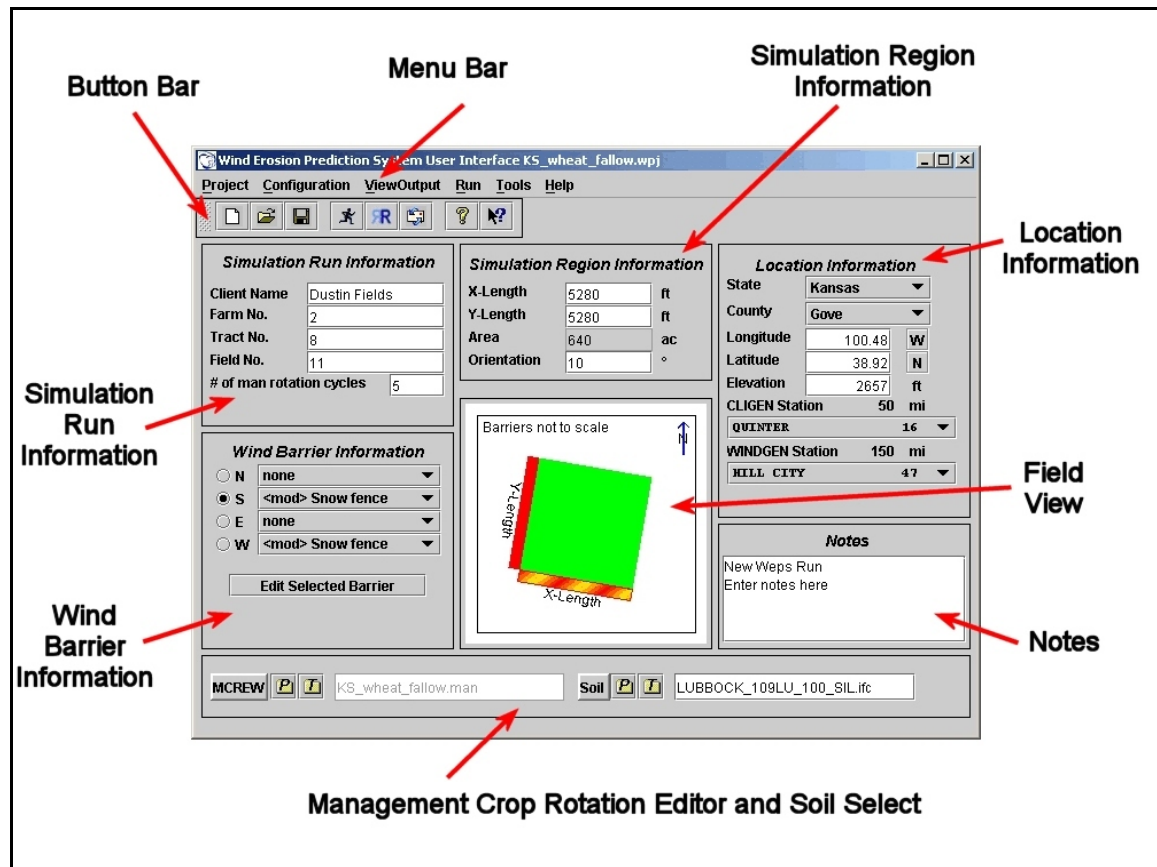
# HOW TO OPERATE WEPS







## Main Screen



**Figure 4.1.** Main screen of the Wind Erosion Prediction System.

This is the WEPS main screen (Fig. 4.1) which should appear at the model startup. Each section of the main screen is labeled with regard to its function. A description of each section is in this User Manual.



## Toolbars




### Menu Bar



This is the top line of the WEPS main screen. A description of each item on the menu bar is given below.

#### Project


The ‘Project’ menu brings up a drop down list of various operations pertaining to WEPS projects. The Project menu contains the following options:

- ▶  New - allows user to create a new project from scratch (Ctrl-N).
- ▶  Open - opens an existing project (Ctrl-O).
- ▶  Save - saves the currently displayed project to its current file name (Ctrl-S).
- ▶ Save As - saves currently displayed project.
- ▶ Exit - exit the WEPS program (Ctrl-X).

#### Configuration

The ‘Configuration’ menu currently has only one item, ‘Edit Configuration’ which brings up a tabbed window with various configuration options for WEPS.

- ▶ ‘Miscellaneous’ - opens a tab that allows the user to set the following:
  - Display either Metric or English units on WEPS screens.
  - Enter the number of time steps used for the daily distribution of simulated wind speed.
  - Check box to display the latitude and longitude fields button in the “Location Information” panel on the Main screen. Un-checking the box, hides these fields.
  - Check box to display the state and county fields button in the “Location Information” panel on the Main screen. Un-checking the box, hides these fields.
  - Check box to display the ‘Use Map’ button in the “Location Information” panel on the Main screen. Un-checking the box, hides this button.
  - Maximum distance search radius for the climate station choice lists (kilometers or miles). Typically one uses the closest, but the user may want to select a station more typical of the climate for the field being simulated. An example of not selecting the closest station might occur in mountainous areas where the adjacent station does not typify the climate for the simulated field.

- Tooltip delays sets the delay time for the initial appearance of the tooltip and for the dismissal of the tooltip box from the screen.
- ▶ ‘Output’ - opens a tab that allows the user to set the following output options:
  - Reporting period for detailed submodel reports.
  - Flags for submodel reports which give model developers and selected users more detailed output than is available through the interface. See the Appendix for flag numbers to set for submodel reports.
- ▶ ‘Email’ - opens email configuration settings:
  - Sender Addr - enter the default email address of the sender.
  - SMTP Server - enter your mailhost SMTP server address.
  - Comments - enter a default recipient for comments to the WEPS developers.
  - Bugs - enter a default recipient for a bug report.
- ▶ ‘Run’ - opens a tab with run options:
  - Run Length Type - click a button to select a type of run length as either the NRCS method (specifies a fixed number of cycles), use simulation run start and end dates on the main screen, or specify the use of rotation cycles on the main screen.
  - Alternative weather files - click the check box next to the name of a weather file type to use alternative weather file (e.g. measured wind data). Then enter the file name and path or choose the file by clicking the folder icon .
- ▶ ‘Executables’ - opens a tab that allows the user to select executable files and command line arguments:
  - WindGen.exe - enter the path and file name for the default Windgen executable.
  - WindGen cmd - enter the default Windgen command line arguments (see Appendix for argument list).
  - CliGen.exe - enter the path and file name for the default Cligen executable.
  - CliGen cmd - enter the default Cligen command line arguments (see Appendix for argument list).
  - WEPS.exe - enter the path and file name for the default WEPS executable.
  - WEPS cmd - enter the default WEPS command line arguments (see Appendix for argument list).
- ▶ ‘Directories’ - opens a tab that allows the user to select the directories used for templates, skeleton files, databases, and projects:
  - Man Template - enter the default directory for the management templates.
  - Man Skeleton - enter the default directory for the management skeleton files.
  - Man Op DB - enter the default directory for the management operation database files.
  - Crop DB - enter the default directory for the crop database files.
  - MCREW Dir - enter the default directory for the MCREW configuration files.
  - Soil DB - enter the default directory for the soil database files.

- Projects Dir - enter the default directory for the project directories and files.

At the bottom of this panel are three buttons:

- ▶ OK - closes the configuration window.
- ▶ Save - saves any changes to the configuration window.
- ▶ Help - opens general help for the configuration window.

### ViewOutput

This menu allows the user to view output for the current and previous runs.

- ▶ Current Run' - clicking on this menu item opens a list of output options.
  - Project Summary' - open a brief output summary for the current project (Ctrl+Shift-P).
  - Crop Summary' - open a summary of yield parameters for the current project (Ctrl+Shift-Y).
  - Management Summary' - open a summary of management operations for the current project (Ctrl+Shift-M).
  - Detailed Reports' - open a detailed output for the current run (Ctrl+Shift-R).
  - Raw Output' - open the raw output file used to create the detailed reports (Ctrl+Shift-O).
- ▶ Previous Run' - clicking on this menu item opens the following list of output option.
  - Project Summary' - open a brief output summary of a previous run project (Ctrl+Alt-P).
  - Crop Summary' - open a summary of yield parameters for a previous run project (Ctrl+Alt-Y).
  - Management Summary' - open a summary of management operations for a previous run project (Ctrl+Alt-M).
  - Detailed Reports' - open the detailed output for a previous run project (Ctrl+Alt-R).
  - Raw Output' - open the raw output file used to create the detailed report for a previous run project (Ctrl+Alt-O).

### Run

This allows the user to run WEPS using the current project or restore other projects. The 'Run' menu on the WEPS Main Screen brings up the following options:

- ▶ Make a WEPS Run' - begin a simulation.
- ▶ Restore a WEPS Run' - restores a previously loaded WEPS project.

### Tools

This menu contain various tools available for use with WEPS including:

- ▶ ‘Send Email’ - send email comments to WERU, providing the computer is connected to the Internet. The user can also attach the current project and run files.

### Help

This menu contains help options for WEPS including:


- ▶ ‘About WEPS’ - gives the current version of WEPS.
- ▶ ‘Help Topics’ - brings up a window containing the WEPS online help system.


### **Button Bar**




At the top of the main WEPS window (below the menu bar) is a series of buttons with icons, designed to help the user in the operation of WEPS.


### *Project Operations*


 This button allows user to create a new project from scratch. This has the same function as selecting ‘New’ under ‘Project’ on the menu bar.


 This button opens an existing project. This has the same function as selecting ‘Open’ under ‘Project’ on the menu bar.

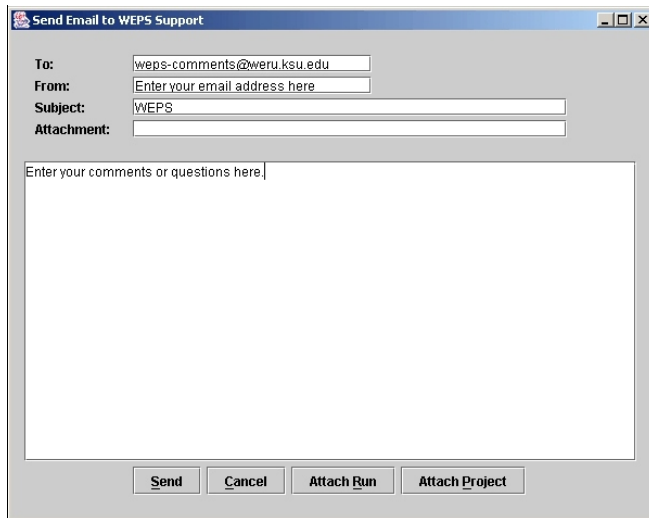
 This button saves the currently displayed project to its current file name. This has the same function as selecting ‘Save’ under ‘Project’ on the menu bar.

### *Run and Help*

 This ‘Run’ button begins a simulation run.

 ‘Reload’ button allows the user to view the output window.

 ‘Email’ button allows the user to email comments to WERU along with the contents of the current Project, if desired. Clicking the ‘email’ button brings up a separate window (see below).



The user should enter an email address and a short message. Click the appropriate box at the bottom of the window to attach the current project and/or run files to your email. If you are connected to the Internet, clicking ‘Send’ will email the message to WERU, along with any attached files so that your enquiry can be answered.



‘Question’ button opens the general help system for WEPS.

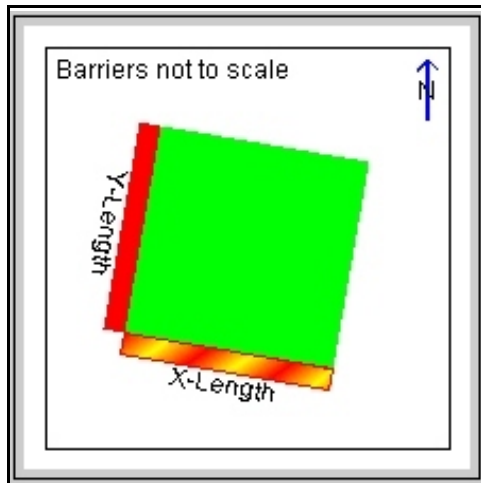


‘Context Help’ button provides help for a particular item on the WEPS screen. Clicking the ‘Context Help’ button on the tool bar and then clicking on the item on the screen for which help is desired brings up a help screen for that item.





### Field View



**Figure 4.2.** Filed View Panel.

The Field View Panel (Fig 1.2) is located in the center of the WEPS1.0 main screen. It is designed to give the user a view of the field size, shape, and orientation (green). The placement of any barriers present is also displayed (red). Note that if the ratio of length to width of the field or barriers is too great to display to scale, this will be indicated within the panel and an approximation of the field or barrier shape will be displayed. This panel is for viewing only and is not editable.

### Simulation Run Information

The image shows a form titled 'Simulation Run Information'. It contains five input fields: 'Client Name' with the value 'Dustin Fields', 'Farm No.' with the value '2', 'Tract No.' with the value '8', 'Field No.' with the value '12', and 'NRCS mode' which is currently empty.

**Figure 4.3.** Simulation Run Information Panel.

Customer information for a simulation run is entered by using the left panel of the WEPS1.0 main screen (Fig. 4.3) labeled 'Simulation Run Information'.

The Client Name as well as the Farm, Tract, and Field Number for the simulation run can be entered by typing the information in the appropriate box in the panel. Note that there are three options for run length type. The NRCS mode specifies a fixed number of cycles. This option is locked for NRCS field use. Other users can specify a simulation run start date and end date on the main screen, or


specify the number of rotation cycles to use on the main screen. The length of run is controlled through the 'Run' tab on the 'Configuration' panel (see the discussion on 'Configuration' for more details).




### Wind Barrier Information



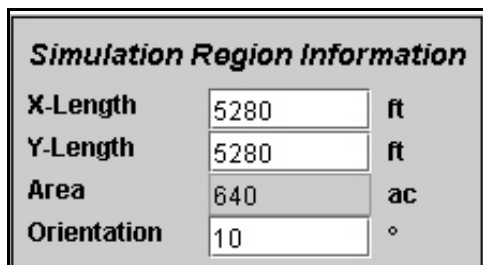
The screenshot shows a panel titled "Wind Barrier Information". It contains four radio buttons labeled N, S, E, and W. The 'N' radio button is selected. To the right of each radio button is a dropdown menu. The 'N' dropdown shows "Shrubs w/o leaves(1 r...". The 'S', 'E', and 'W' dropdowns all show "none". At the bottom of the panel is a button labeled "Edit Selected Barrier".

**Figure 4.4.** Wind Barrier Information panel.

The wind barrier panel (Fig. 4.4) is used to add barriers to the field borders. Note that WEPS1.0 only allows barriers on the borders of the field. The barrier for each field border is labeled 'N' for north, 'S' for south, 'E' for east, and 'W' for west. The barrier type can be selected from the drop down list in the panel by clicking the down arrow  to the right of the barrier type to bring up the list of available barriers and clicking on the appropriate barrier. Once a barrier type is selected, the barrier properties may be viewed and edited by clicking the 'Edit Selected Barrier' button at the bottom of the panel. A separate panel is opened where one may enter the barrier width, height, and porosity in the

appropriate space. Note that the area of the barrier is displayed but cannot be edited. If barrier properties are modified, it will be noted in the type list with a '<mod>' designation before the type name. {If a barrier other than 'None' is selected but 'Edit Selected Barrier' button does not open the properties panel, please click the radio button off , then on  again.} To remove a barrier from the field, click the radio button  to select it (notice the barrier will be 'highlighted' when selected) then select the barrier type 'None' to remove it.

### Simulation Region Information



The screenshot shows a panel titled "Simulation Region Information". It contains four input fields with labels to their left: "X-Length", "Y-Length", "Area", and "Orientation". The "X-Length" and "Y-Length" fields contain the value "5280" and are followed by the unit "ft". The "Area" field contains the value "640" and is followed by the unit "ac". The "Orientation" field contains the value "10" and is followed by the unit "°".

**Figure 4.5.** Simulation Region Information panel.

The 'Simulation Region Information' panel is shown in Figure 4.5. To describe the simulation region, the field dimensions are entered as an X-Length and a Y-Length. Note that the area of the region will be displayed but can not be edited. To orient the field direction, simply type in the angle in degrees of deviation from north of the field. Note that the field will only rotate in a range of  $\pm 45$  degrees. By rotating and adjusting the field length and width, the user should be able to obtain the

desired field size and orientation. Creating special shapes or configurations such as circles and strip cropping are discussed under "Using WEPS for Conservation Planning".

### Choosing a Location

Choosing a location within WEPS defines the physical location of the field to be simulated. This location information is used within WEPS to select the weather stations (CLIGEN and WINDGEN) to be used for the simulation.

**Location Information**

State: **Kansas** ▼

County: **Ford** ▼

Longitude:  **W**

Latitude:  **N**

Elevation:  **ft**

CLIGEN Station: **50 mi**

**CIMARRON**  ▼

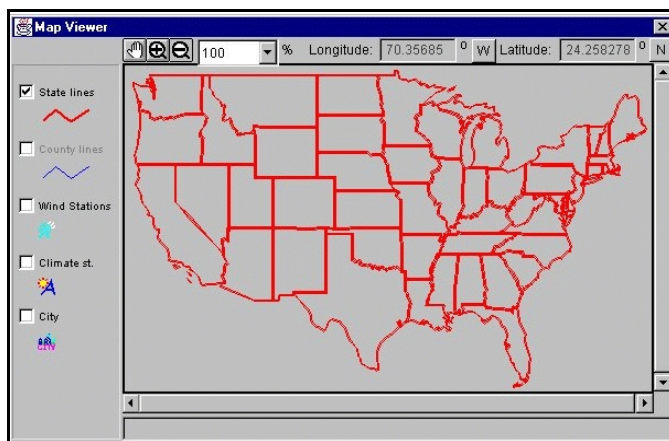
WINDGEN Station: **150 mi**

**DODGE CITY (AWOS)**  ▼

**Figure 4.6.** 'Location Information' Panel.


Location information is entered through the rightmost panel labeled 'Location Information' on the main interface screen (Fig. 4.6). Select the state and county of interest from the drop down list by clicking the down arrow ▼ to the right of the state and county. The CLIGEN and WINDGEN stations nearest to the center of the selected county will then be determined by the interface and listed. The longitude and latitude of the location can also be entered, which will bring up the nearest CLIGEN and WINDGEN stations. Once the stations are displayed, the user can click on the down arrow ▼ next to the stations to bring up a list of nearby stations from which to choose an alternative station if desired. The State and County as well as the Longitude and Latitude fields are optional and can be added to or removed from the interface through the

'Miscellaneous' tab of the 'Configuration' panel (see the discussion on 'Configuration' for more details). {Right clicking on the listed CLIGEN or WINDGEN station name will bring up information about the weather station. This information may be useful in determining which station best fits the location and conditions desired. This feature is not currently implemented.}

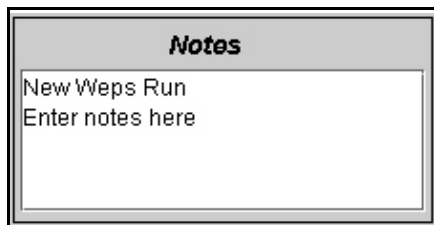


**Figure 4.7.** Map Viewer window.

An alternative method to choosing a location is by using the map. Clicking on the 'Use Map' button brings up 'Map Viewer' with a map of the United States (Fig. 4.7). The map can be 'zoomed' in or out by selecting a % magnification from the dropdown list ▼ at the top the map viewer screen. Alternatively, the user may increase or decrease magnification by clicking the zoom in 🔍 or zoom out 🔍 buttons and

then clicking a location within the map window. When zoomed to greater than 100%, one can 'drag' the view of the map by clicking on the 'move' icon  then holding down the left mouse button and drag the map view to the desired location. Clicking the check boxes in the left side of the Map Viewer window will display county lines (must be zoomed at 400% or greater), the location of CLIGEN stations, WINDGEN stations, and major cities on the map. Double clicking a location on the map will select the nearest CLIGEN and WINDGEN station and close the map viewer. The map viewer is a convenient way to view all of the climate stations within a state or region. {Note! This feature is not currently implemented.}

### Notes



The user may also type in notes for the run in the 'Notes' panel (Fig. 4.8). These notes will be displayed and can be edited on the Project Summary output report.


**Figure 4.8.** 'Notes' Panel.

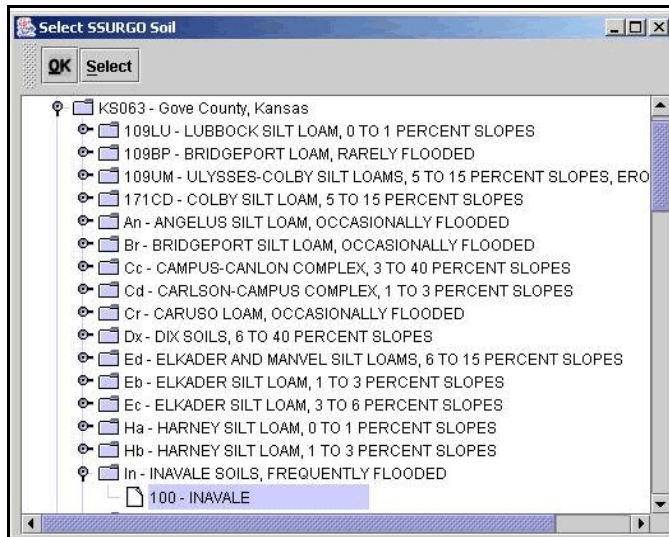
## Choosing a Soil

A soil for a simulation run is selected using the ‘Soil:’ box on the right side of the bottom panel of the WEPS1.0 main screen (Fig. 4.9).






**Figure 4.9.** Bottom panel of the WEPS main screen with the soil box on the right.

The soil for a simulation run can be selected from the NRCS SSURGO database by clicking the ‘Template folder’  to the left of the soil name.



**Figure 4.10.** The ‘Select SSURGO Soil’ window.

Clicking the Template folder will open a window titled ‘Select SSURGO Soil’ (Fig. 4.10). Navigate through the database tree to click the soil survey area (county) desired. The soils files are listed according to the soil map unit symbol, soil map unit name, surface texture, and local phase. Selecting a soil then lists its components and the percent each component contributes to the map unit. Click a soil component to highlight it and click the ‘Select’ button  at the top of the screen. Clicking the ‘OK’ button  converts the soil from the SSURGO database to a

WEPS soil file format (with an ‘ifc’ extension) and loaded. The loaded soil file name will appear in the soil box window. Soils that have been previously loaded to projects or modified and saved to another name can be opened by clicking on the “Project folder” . This will open a window where the user can select the desired soil or type in the soil file name.

To view the soil data, double click on the button labeled ‘Soil’, on the left side of the soil box. This will open the WEPS Soil User Interface screen (Fig. 4.13), which allows the user to view, edit, and save the soil information under a new file name under the project.



WEPS SOIL WEPS Soil Layers M:\nasdb\Kansas\SewardKS.nas

File Edit View Help

Colby-Cc-100-L

State	County	Soil Survey Area Name	Soil Survey ID	Map Unit Symbol	Component Name	Component Percent	Soil Order	#of Layers
KS	Seward	Seward County, Kansas	KS175	Cc	Colby	100	entisols	3

Soil Surface Properties									
Soil Crust				Loose Material on Crust		Roughness	Ridge		
Thickness	Density	Stability	Fraction	Mass	Cover Fraction	Random	Orientation	Height	Spacing
mm	Mg/m <sup>3</sup>	ln(J/kg)	m <sup>2</sup> /m <sup>2</sup>	kg/m <sup>2</sup>	m <sup>2</sup> /m <sup>2</sup>	mm	degrees	mm	mm
0.010	1.725	3.077	0.000	0.000	0.000	4.000	0.000	0.000	0.000

Soil Layer Properties										
Thickness					Sand Fractions					Dry
	Sand	Silt	Clay	Rock	Coarse	Medium	Fine	Very Fine		
mm	--- kg/kg ---				m <sup>3</sup> /m <sup>3</sup>	--- kg/kg ---				
1	150	0.250	0.540	0.210	0.000	0.025	0.015	0.045	0.140	1.380
2	150	0.250	0.540	0.210	0.000	0.025	0.015	0.045	0.140	1.380
3	1170	0.170	0.605	0.225	0.000	0.003	0.002	0.030	0.130	1.380

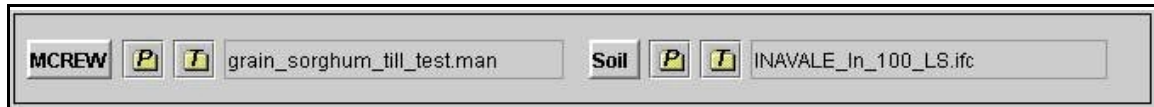
Figure 4.13. WEPS Soil User Interface screen.








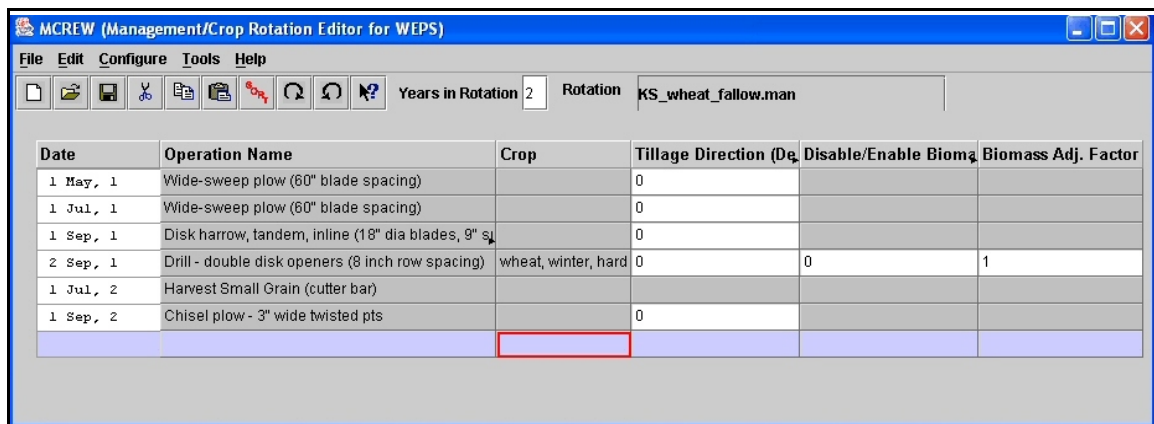
### Choosing and Editing a Management Rotation

Management rotation scenarios for a simulation run can be selected or a rotation editor can be opened by using the 'MCREW' box on the left side of the bottom panel of the WEPS main screen (Fig 4.1).



**Figure 4.14.** Bottom panel of the WEPS main screen with the management box on the left.

A management rotation for a simulation run can be selected from pre-generated management files. Click the template folder  in the management box which is located in the bottom panel of the main screen (Fig. 4.1) and then select the management rotation desired from the template directory. Once selected, the name of the management file will appear in the panel. The user may also select management files stored in project directory by clicking on the project folder . Usually, management rotation files in a WEPS project are simply copies of those selected from the "Template" directory, but they may have local "project specific" modifications. To open the Management Crop Rotation Editor for WEPS (MCREW), double click on the 'MCREW' button , on the left side of the management box. This will open the MCREW window (Fig. 4.2), which allows the user to view, edit, and save management rotation information under a new file name.



**Figure 4.15.** Management Crop Rotation Editor for WEPS (MCREW) window.

MCREW's principle purpose is to create/modify/construct management rotation files required for making WEPS simulation runs. Although it is an integral component of the WEPS 1.0 interface, it can be used as a stand alone program to edit management rotation

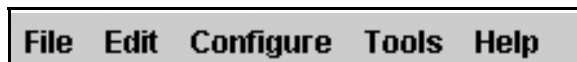
files independent of the WEPS and was designed to be configurable for uses outside of WEPS. Much of MCREW's functionality, behavior and visual appearance is controlled via ASCII XML-format configuration files. Changing the appropriate configuration files allows one to specify the structure and definition of the management/crop rotation file format and the user's ability to view and edit specific operation and/or crop properties, etc.

MCREW is fundamentally a date ordered list of management operations. This release of MCREW provides the user with a tabular, row oriented view of the operations and their associated dates. In WEPS, a management operation is defined as any human initiated process, such as a tillage event, seeding, irrigation setting, etc. If the operation triggers the WEPS model to start simulating the growth of a crop (or any other plant vegetation supported with a crop database record containing the necessary vegetation growth parameters), e.g. a planting/seeding/transplanting operation, then the name of that crop is listed in the row next to the name of the operation.

### Using MCREW

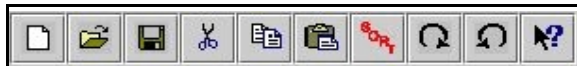
MCREW is designed to allow easy creation and editing of management rotation files for WEPS. The MCREW screen consists of 5 major components:

1. Menu bar



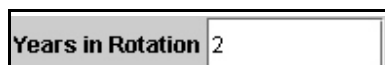
The menu bar consists of assorted menu options which provide access to MCREW's functions. Functions of the menu bar are discussed later in this document.

2. Button bar



The Button toolbar consists primarily of buttons that provide quick access to some of MCREW's most common functions. Functions of the buttons are discussed later in this document.

3. Years in Rotation



On the right of the button bar, the user may view and edit the number of years in a rotation cycle.

#### 4. Rotation



This window displays the name of the management rotation which is loaded. If the management rotation name is too large, a scroll bar is provided so the user can view the entire rotation name.

#### 5. Table View

Date	Operation Name	Crops	Tillage Direction	Target Yield
May 15, 1	Wide-sweep plow (60" blade spacing)		0.5	
Jul 15, 1	Wide-sweep plow (60" blade spacing)		0.5	
Sep 1, 1	Disk harrow, tandem, inline (18" dia blades,		0.75	
Sep 25, 1	Drill - double disk openers (8" row spacing)	wheat, winter, hard	0.4	0.00
Jul 20, 2	Harvest Small Grain (stripper)			
Jan 1, 1				

The Table View displays the sequence of operations with their associated dates and any crops planted in a tabular format. Spreadsheet style editing functions are available to manipulate the order, selection, and removal of operations and/or crops, etc. More details of the editing functions of the Table View are given later in this section.

### Opening and Saving MCREW files

In WEPS 1.0, there are two primary locations that management rotation files exist:

#### 1. In the "Management Templates" directory.

This is the location that complete or partial (single or multi-crop year) management rotation files are kept. Files in this directory always show up on the management rotation selection choice lists. Typically, management rotation files to be used in WEPS projects are selected from previously built management rotation files or are constructed from several partial management rotation files located in this directory.

#### 2. Within a "WEPS Projects" directory.

The management rotation file used in a WEPS run is always located in that WEPS project's directory. There can be more than one management rotation file in a WEPS project. The current management rotation file to be used when making a WEPS run is the one specified in the "weps.run" file (e.g., the one listed in the "management" input field on the WEPS main screen. Usually, management rotation files in a WEPS project are simply copies of those selected from the "Template" directory, but they may have local "project specific" modifications.

## Menu Bar Functions

### File

Once the user is in MCREW, rotation files can be saved in the desired location and/or other rotation files opened for editing. The "File" menu contains all of these options, with the common functions ("New", "Open", and "Save") also being available on the icon button toolbar:



- New  
Opens an empty unnamed rotation file.
- Open  
Brings up an "Open File" dialog box from which the user can select the desired rotation file from those in the current project.

- Open Copy of Template  
Brings up an "Open File" dialog box from which the user can select the desired rotation file from the "Management Templates" directory. A copy of the selected file is then added to the current WEPS project and made available for editing in MCREW.
- Save  
Saves the current project's rotation file being edited.
- Save As  
Brings up a "Save File" dialog box from which the user can specify the desired filename to save the rotation file for the current project.

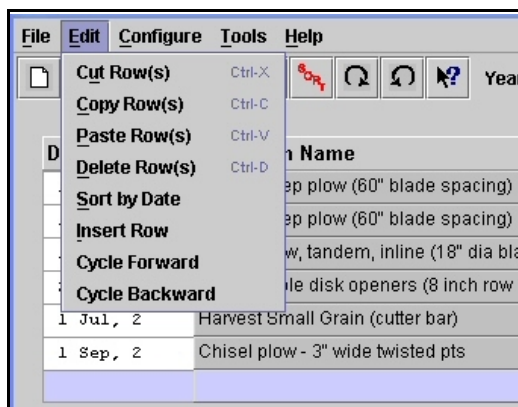
- **Save As Template**  
Brings up a “Save File” dialog box from which the user can specify the desired filename to save the rotation file into the “Management Templates” directory.
- **Exit**  
Exits MCREW. If MCREW finds that the rotation file has been modified and not saved, it will display a popup message and ask the user if they want to save it before leaving.

**NOTE:** Currently when one “Saves” a management rotation file for the current WEPS project, that file is not physically saved into the current project’s directory until the project itself is saved via the WEPS main screen menu “Save” option or automatically prior to initiating a WEPS run. Thus, a remote possibility exists for a “saved” WEPS management rotation file to disappear if the computer crashes prior to “saving” the current project. This will be corrected in a future release.

## Edit

A WEPS 1.0 rotation file is simply a date-ordered list of management operations. MCREW provides basic editing functionality to insert, delete, modify, and change dates for those operations. In WEPS, each operation is defined by a list of physical processes, such as residue burial, soil inversion, flattening standing residue, creation of ridges, planting a crop, etc., which are described to the model via one or more parameter values.

In it’s most basic form then, one can “see” a WEPS management rotation file within MCREW via the table view.



The primary editing functions available are accessible via the ‘Edit’ menu option. The table view editing functions are:

- **Cut Row(s) (Ctrl-X)**  
Remove the currently selected operation row(s) from the rotation and store them in a temporary buffer for possible pasting back into the rotation later.
- **Copy Row(s) (Ctrl-C)**

Copy the selected operation row(s) from the rotation and store in a temporary buffer for possible future pasting back into the rotation.

- Paste Row(s) (Ctrl+Shift-V)  
Paste the previously cut or copied operation row(s) above the selected operation (or top one if more than one is selected).
- Delete Row(s) (Ctrl-D)  
Delete the selected operation row(s) (or bottom one if more than one is selected).

The “Cut”, “Copy”, and “Paste” buttons on the toolbar can also be used for those operations.

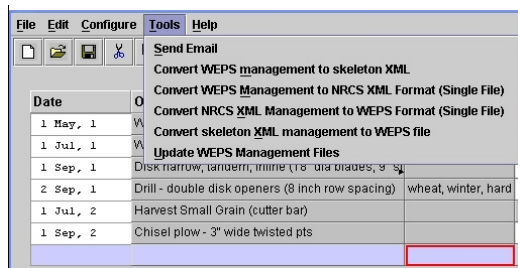
- Sort by Date  
Sort the operations in ascending order by date. See “Management File Date Adjustment Functions” below.
- Insert Row  
Insert a blank row above the selected row.
- Cycle Forward  
Selecting this option causes the last year in the rotation to become the first year in the rotation while the other rotation years cycle down one year. See “Management File Date Adjustment Functions” below.
- Cycle Backward  
Selecting this option causes the first year in the rotation to become the last year in the rotation while the other rotation years cycle up one year. See “Management File Date Adjustment Functions” below.

## **Configure**

This menu item is not implemented.

## **Tools**

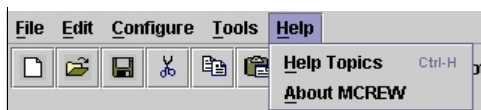
The ‘Tools’ menu item lists many tools and utilities related to the use of MCREW.



- Send Email  
Provides a method to communicate with WEPS developers via email.
- Convert WEPS management to skeleton XML  
Converts multiple WEPS management files in a single directory to the NRCS shared summary management file format.

- Convert WEPS Management to NRCS XML Format (Single File)  
Converts a single WEPS management file to the NRCS shared summary management file format.
- Convert NRCS XML Managemnet to WEPS Format (Single File)  
Converts single NRCS shared summary management files to the WEPS management file format.
- Convert skeleton XML management to WEPS file  
Converts multiple NRCS shared summary management files to the WEPS management file format.
- Uppdate WEPS Management Files  
Updates management files with the most current crop and operation database parameters.

## Help



The 'Help' menu item displays help options about MCREW and includes:

- Help Topics  
Opens a window containing the MCREW online help system.
- About MCREW  
Displays the current version of MCREW.

### Editing via the Table View

#### Row and Cell Selection Functions

The mouse is currently the primary method used to "select" either a row and/or an individual table cell. If a particular table cell cannot be directly edited, this is indicated by a gray background, (e.g., Operation Name or Crop) and the row is selected (indicated by the dark blue background in all cells within the row)

Date	Operation Name	Crop
1 Jun, 1	Wide-sweep plow (60 inch blade spacing)	
15 Jul, 1	Wide-sweep plow (60 inch blade spacing)	
30 Aug, 1	Rodweeder	
15 Sep, 1	Drill, air seeder, chisel opener (12 inch row s	wheat, winter, hard

along with the individual cell (indicated by the red rectangular border around the cell). See the figure to the left for an example of a row selection after the user did a left mouse click on the "Rodweeder" operation cell.

If the table cell can be directly edited on the table (indicated by a white background in the table cell), then a left mouse button selection will select the individual cell and immediately allow the user to manually "edit" the value in the cell. The figure to the left shows an

30 Aug, 1	Rodweeder
15/9/1	Drill, air seeder, chisel opener (12
25 Jul, 2	Harvest Small Grain (cutter bar)

example of selecting a date cell for editing (date format changes to a numerical display for manual keyboard editing of the value - Note that the cursor doesn't display in this screen shot).

One can select multiple rows at one time by depressing and holding down the left mouse button on the first row to be selected and dragging the mouse cursor over the additional contiguous rows to also be selected. Release the left mouse button on the last row to be

15 Sep, 1	Drill, air seeder, chisel opener (12 inch row s	wheat, winter, hard
25 Jul, 2	Harvest Small Grain (cutter bar)	
10 May, 3	Planter - double disk openers (30 inch row s	corn, grain, 100
15 Oct, 3	Harvest (cut or break stalks high)	
15 Apr, 4	Wide-sweep plow (60 inch blade spacing)	
20 May, 4	Wide-sweep plow (60 inch blade spacing)	
1 Jun, 4	Planter - double disk openers (30 inch row s	sunflower

selected. All selected rows will be highlighted with a light blue background. The cell the mouse cursor was in when first depressing the left mouse button will be identified by the red rectangular border around it (see the figure to the left).

One can append contiguous rows adjacent to a previous, row or multi-row selection, by holding down the "shift" key and clicking the left mouse button on the last desired contiguous row to append to the selection. This is similar to how Microsoft Windows append selection works with the "shift" key depressed.



Similarly, one can append non-contiguous rows (or row) by holding down the "ctrl" key and making an additional multi-row (or single row) selection similar to the original row or multi-row selection (see figure to the left).

Date	Operation Name	Crop
1 Jun, 1	Wide-sweep plow (60 inch blade spacing)	
15 Jul, 1	Wide-sweep plow (60 inch blade spacing)	
30 Aug, 1	Rodweeder	
15 Sep, 1	Drill, air seeder, chisel opener (12 inch row s	wheat, winter, hard
25 Jul, 2	Harvest Small Grain (cutter bar)	
10 May, 3	Planter - double disk openers (30 inch row s	corn, grain, 100
15 Oct, 3	Harvest (cut or break stalks high)	
15 Apr, 4	Wide-sweep plow (60 inch blade spacing)	
20 May, 4	Wide-sweep plow (60 inch blade spacing)	
1 Jun, 4	Planter - double disk openers (30 inch row s	sunflower
1 Jul, 4	Cultivator, row crop, 30 inch row spacing (3 i	
30 Aug, 4	Harvest (cut or break stalks high)	

As many non-contiguous rows can be selected, as desired, via this method. Again this is similar to how Microsoft Windows non-contiguous selection method works with the "ctrl" key depressed.

Any row or multi-row selection can be de-selected and replaced by simply clicking the left mouse button anywhere within the MCREW table display (with no keyboard keys depressed).

### Row Editing Functions

30 Aug, 1	Rodweeder	
15 Sep, 1	Drill, air seeder, chisel opener (12 inch row s	wheat, winter, hard
25 Jul, 2	Harvest Small Grain (cutter bar)	
10 May, 3	Planter - double disk openers (30 inch row s	
15 Oct, 3	Harvest (cut or break stalks high)	
15 Apr, 4	Wide-sweep plow (60 inch blade spacing)	
20 May, 4	Wide-sweep plow (60 inch blade spacing)	
1 Jun, 4	Planter - double disk openers (30 inch row s	
1 Jul, 4	Cultivator, row crop, 30 inch row spacing (3 i	
30 Aug, 4	Harvest (cut or break stalks high)	

The user can "Insert" a new blank row immediately above the row containing the cell identified with the red rectangular box. Additionally, one can depress the right mouse button to display a popup menu that contains row editing functions (see the figure to the left).

30 Aug, 1	Rodweeder	
15 Sep, 1	Drill, air seeder, chisel opener (12 inch row s	wheat, winter, hard
25 Jul, 2	Harvest Small Grain (cutter bar)	
10 May, 3	Planter - double disk openers (30 inch row s	
15 Oct, 3	Harvest (cut or break stalks high)	
15 Apr, 4	Wide-sweep plow (60 inch blade spacing)	
20 May, 4	Wide-sweep plow (60 inch blade spacing)	
1 Jun, 4	Planter - double disk openers (30 inch row s	
1 Jul, 4	Cultivator, row crop, 30 inch row spacing (3 i	
30 Aug, 4	Harvest (cut or break stalks high)	

Besides duplicating the cut, copy, paste, delete and insert row functions mentioned above in the "Edit" menu bar, one can also adjust the operation dates on the selected rows. Selecting the "Adjust Date" option will popup a dialog box allowing the user to adjust the operation dates in the selected rows by a specified  $\pm$  number of days, months, or years (see the figure to the left).

Also, one can insert the contents of another (previously created) management file via the "Insert Management File" option immediately above the row containing the cell identified with the red rectangular box. The "FileChooser" dialog will popup allowing the user to select the desired management file from which to include all the operations and their associated dates from into the current management file being edited.

### Management File Date Adjustment Functions

There are several date adjustment functions available in MCREW that apply to the entire list of management operations. They are available via the "Edit" menu and the icon toolbar. The operations are:

- a) Sort by Date
- b) Cycle Forward
- c) Cycle Backward

The "Sort by Date" function sorts the management operations by ascending date order. Thus, the user can adjust/set the dates of management operations without having to worry about whether they are in the correct sequential order at that time. When the user wants to see the list of operations in the correct date ordered format, they can simply select the "Sort by Date" function from the toolbar icon or the "Edit" menu.

MCREW will not allow the user to save a WEPS management file without the operations being listed in date order. The user is given the options to automatically sort them if they are not sorted during a management file save operation or to go back to the editor and allow the user to correct the problem(s) manually.

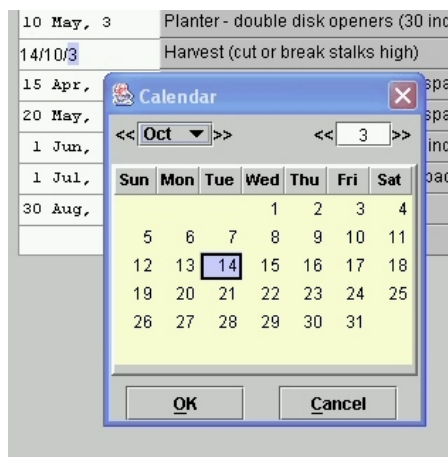
The "Cycle Forward" and "Cycle Backward" functions will rotate the "rotation year" of the management operation dates forward or backward in increments of one year. For example, a three year management file rotation "Cycled Forward" would change the operation dates in the first year to the 2nd year, those in the 2nd year to the 3rd year and those in the 3rd year to the 1st year. Thus, the crops grown and harvested in the first year would now occur in the second year, etc. Likewise, a rotation "Cycled Backward" would shift the rotation the opposite direction, making the 2nd year operations occur in the first year, etc.



### Date Column Editing Functions

Besides the "Adjust Date" function discussed in the Row Editing section, there are additional date editing functions available. Clicking the right mouse button while the cursor is on an operation date cell, causes a date editing popup menu to appear (see the figure to the left). The multi-purpose, generic "Adjust Date" function is also available from this menu, but year, month, week, and day increment and decrement functions are also available. They apply to all dates

that are "selected" (displayed with the light blue background in their cells for multi-row selections or an individual date cell identified with the red rectangular box around it).

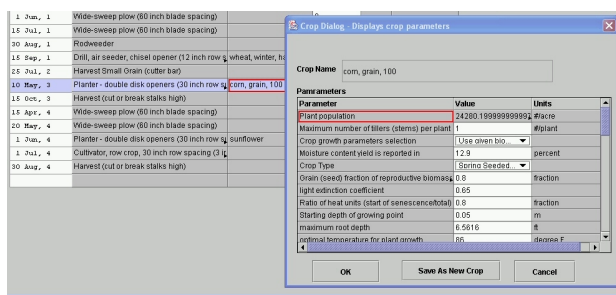
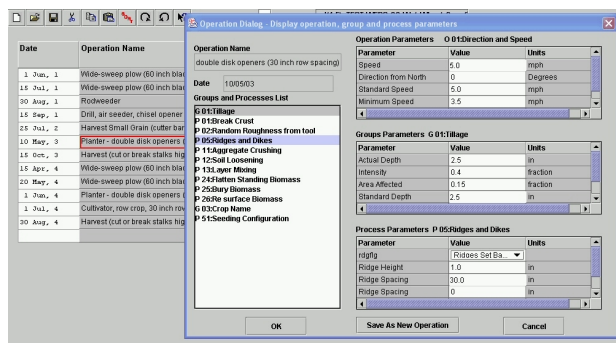


If the user does a double left mouse click in a date cell, a popup calendar is displayed that allows the user to select the desired date. The calendar allows the user to increment or decrement the month and year values if desired and then select the day of the operation within that month/year. The user can either double right mouse click on the day value or click on the "OK" button to accept the specified date (see the figure to the left).

## Operation and Crop Drilldown Screens

Both the Operation and Crop cells have a "drilldown" function available that allows the user to display a popup screen that makes many of their specific parameter values viewable and/or editable. The specific content of these screens depend both upon the type of crop or

operation and specific XML-format configuration files which describe which parameters are to be made viewable or hidden to the user and if viewable, whether or not they are editable by the user. In addition, for each parameter that is displayed, the prompt information for the parameter is described in these XML-format files. Examples of operation and crop drilldown screens are shown to the left.



The cell-specific drilldown functions are available for single cell selections (right mouse button click - red rectangular box around the selected cell) and for the identified single cell selection (red rectangular box around the cell) when a multi-row selection has been defined via the left mouse button selection method.

The operation drilldown screen is accessible if the selected cell is in the operation column and a crop drilldown screen is accessible if the selected cell is in the crop column.

### **Selecting/Replacing Operations and Crops**

A new operation can be added to a blank line or a different operation can be selected to replace an existing operation. This is accomplished by double clicking the left mouse button with the mouse cursor in an operation cell. This action will popup the "FileChooser" dialog. It allows the user to select a management operation record from within the window. The user can also access this "FileChooser" dialog from the "Add/Change Operation" menu option via the right or left mouse menus (described earlier under "Row Editing Functions").

A Crop can be specified for planting (and subsequent harvest) only for operations which contain the "planting/seeding" process. Those that have this process defined will either display the name of the crop to be planted in the "crop" column or display the string "no crop", signifying that no crop is to be planted or it hasn't yet been selected by the user. A crop can be added or an existing crop can be replaced by double clicking the left mouse button with the cursor in a crop cell. This action will popup the "FileChooser" dialog. It allows the user to select a crop record from within the window. The user can also access this "FileChooser" dialog from the "Add/Change Crop" menu option via the right or left mouse menus (described earlier under "Row Editing Functions").

## WEPS Output

WEPS provides numerous outputs to aid the user in conservation planning. These outputs are accessed through the 'ViewOutput' menu on the main screen. Clicking on this menu displays two choices, 'Current Run' and 'Previous Run'. Clicking on 'Current Run' displays a list of output options for the current run. The 'Previous Run' choice allows the user to view results of previous runs. A description of the choices under these two submenus follow.

## Project Summary

The Project Summary report screen (Fig. 4.17) will automatically display at the conclusion

**WEPS Project Summary**

Project Name: C:\usr\jtfwork\weps\weps1.install\projects\KS\_wheat\_fallow  
 Run Name: a9 Date Created: Wed Jun 18 10:41:00 CDT 2003  
 Client: Dustin Field  
 Farm No: 5 Tract No: 4 Field No: 123  
 Soil: INAVALE\_In\_100\_LS  
 Management: grain\_sorghum\_till\_test

**Simulation And Site Information**  
 Duration: 1 yrs Mode: cycle  
 Longitude: 100.66 °E Latitude: 38.00 °N  
 County: Finney State: Kansas

**Field Dimension Information**  
 X-Length: 160... Area: 259 ha  
 Y-Length: 160... Orientation: 10 °  
 Site Elevation: 801 ...

**Weather Stations**  
 Cligen Station: CIMARRON  
 Windgen Station: GARDEN CITY MUNI

Period	Crop	Gross Loss (kg/m <sup>2</sup> )	Net Soil Loss From Field (kg/m <sup>2</sup> )			
			Total	Creep/Salt	Suspension	PM10
Rot. yr: 1	sorghum, grain, 130...	46.25	46.25	5.414	40.829	0.8699
Ave. Annual		46.25	46.25	5.414	40.829	0.8699

Barrier Type	Height m	Width m	Porosity frac
S Sorghum (2 row)	2.0	2.0	0.50






New Weeps Run  
Enter notes here

**Figure 4.26.** The WEPS Project Summary screen.

of a simulation run. If the Project Summary screen has been closed, the user can display the Project Summary screen for the current project or previously run projects by clicking the 'ViewOutput' menu on the WEPS main screen menu bar.

The Project Summary contains names of the input files as well as other input parameters and basic soil loss information by rotation year and the average annual for the total simulation. Soil loss output in the Project Summary includes: Gross Loss which is the average erosion within the field; Total which is the average total net loss from the field; Creep/Salt which is the average creep plus saltation net loss from the field; Suspension which is the average suspension net loss from the field; and PM10 which is the average PM10 net loss from the field. If any barriers were present on the field borders, a summary of their properties is also listed. Finally, any notes entered on the main screen for the run are

reproduced and they can be edited or added to if desired.

A button bar is included at the top of the Project Summary screen which allows the user to close the window , save the notes to the summary , print the summary , open general help for the summary , and use the context help .

## Crop Summary

The Crop Summary report screen (Fig. 4.18) contains simulation run information including the names of the input files. It also contains a Detailed Report table and a Summary Report table for each crop grown during the simulation run.

Crop Summary

OK

Project Name

C:\usr\jttwork\weps\weps1.install\projects\KS\_wheat\_fallow

Run Name

a8

Date Created

Tue Jun 17 16:12:52 CDT 2003

Client

Dustin Field

Farm No

123

Tract No

4

Field No

5

Soil

INAVALE\_in\_100\_LS






Management

grain\_sorghum\_till\_test

Rot Cycle	Yr. in Rot.	Harvest Date	Crop Name	Dry Yield lbs/acre	Harvest Index	Wet Yield	Water Percent
1	1	1 Nov 1	sorghum, grain, 130 days	1058	0.786	20.850 bu/ac	9.3
2	1	1 Nov 1	sorghum, grain, 130 days	1145	0.750	22.557 bu/ac	9.3
3	1	1 Nov 1	sorghum, grain, 130 days	1727	0.751	34.030 bu/ac	9.3
4	1	1 Nov 1	sorghum, grain, 130 days	862	0.681	16.989 bu/ac	9.3
5	1	1 Nov 1	sorghum, grain, 130 days	1417	0.759	27.933 bu/ac	9.3

Yr. in Rot.	Harvest Date	Crop Name	Statistic Type	Dry Yield lbs/acre	Harvest Index	Wet Yield
1	1 Nov 1	sorghum, grain, 130	Mean	1242	0.7454	24.4718 bu/ac
			Std Dev	337	0.0388	6.6354 bu/ac
			Minimum	862	0.6810	16.9890 bu/ac
			Maximum	1727	0.7860	34.0300 bu/ac

The Detailed Report table gives crop yield data for each crop year in the simulation. The Summary Report table provides statistical summary parameters for each rotation year. For example, it gives the mean yield for all the simulation years that an individual crop was grown.

A button bar is included at the top of the screen which allows the user to close the window , print the crop detail table , print the crop summary table , open general help for the WEPS , and use the context help .



**Figure 4.27.** The WEPS Crop Summary screen.

## Management Summary

The Management Summary report screen contains simulation run information including names of the input files.

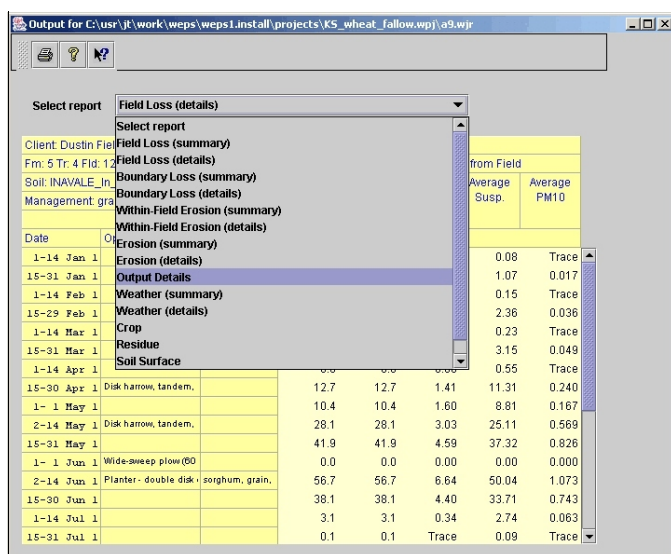
A button bar is included at the top of the Management Summary screen which allows the user to close the window , print the management summary , open general help for the








WEPS , and use the context help .

## Detail Reports

The Detailed Reports screen (Fig. 4.19) provides a choice list where the user can select various types of output. The features of the Detailed Reports Screen are described below.



**Figure 4.28.** The WEPS Detailed Reports screen showing the drop down report list.

A button bar is included at the top of the Detailed Reports screen which allows the user to close the window , print any detail report , open general help for the WEPS , and use the context help . Below the button bar is a drop down report list labeled 'Select report'. Clicking the down arrow  to the right of 'Select report' displays the list of output available. Click the desired list and it will be displayed in the window below. The following is a description of each report screen.

### Output Details

The Output Details report contains all of the erosion, weather, and surface information available by period, by rotation year, and for the entire simulation run.

The **columns** of the Output Details report have the following information.

**Date** - This column contains the start and end dates (day/month/rotation year) of the reporting period.

**Operation** - This column contains the management operation which occurred on the specified date.

### Wind Erosion

**Average Total Gross Soil Loss** - The Average Total Gross Soil Loss is the average

erosion within the field, averaged across the field as well as averaged over the number of simulation years in each rotation year ( $\text{kg}/\text{m}^2$  or tons/acre).

#### Net Soil Loss from Field


Average Total - The average total net loss from the field ( $\text{kg}/\text{m}^2$  or tons/acre).


Average Creep/Sal. - This column contains the total creep plus saltation net loss for the period, averaged across the field grid areas, as well as averaged over the number of simulation years in each year of the crop rotation ( $\text{kg}/\text{m}^2$  or tons/acre).


Average Susp. - This column contains the total suspension net loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year ( $\text{kg}/\text{m}^2$  or tons/acre).

Average PM10 - This column contains the net PM10 soil loss for the period, averaged across the field grid areas as well as averaged over the number of simulation years in each rotation year ( $\text{kg}/\text{m}^2$  or tons/acre).

#### ***Mass of Soil Passing Indicated Field Boundary***

Creep+Saltation - These columns display the average mass of creep plus saltation size material passing each field boundary ( $\text{kg}/\text{m}$  or tons/1000 ft) in the direction indicated .

Suspension - These columns display the average mass of suspension size material passing each field boundary ( $\text{kg}/\text{m}$  or tons/1000 ft) in the direction indicated .

PM10 - These columns display the average mass of PM10 (particulate matter less than 10 microns) size material passing each field boundary ( $\text{kg}/\text{m}$  or tons/1000 ft) in the direction indicated .

#### ***Within Field Wind Erosion Activity***

The information in this section is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

#### Saltation Emission Region

Soil Loss - This column displays the amount of soil loss from that area of the field that



had saltation emission ( $\text{kg/m}^2$  or tons/acre).

Field Area - These columns display both the area (acres or hectares) and fraction of that area of the field that had saltation emission.

#### Deposition Region

Soil Deposition - This column displays the amount of soil deposited in that area of the field where deposition is the primary activity ( $\text{kg/m}^2$  or tons/acre).

Field Area - These columns display both the area (acres or hectares) and fraction of that area of the field that had deposition.

#### High Flux Region

Field Area - These columns display both the area (acres or hectares) and fraction of that area of the field which was near transport capacity.

#### Sheltered Region

Field Area - These columns display both the area (acres or hectares) and fraction of that area of the field that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately downwind of barriers.

#### ***Weather Info***

Average Total Period Precip - This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches).

Average Wind Energy  $>8$  m/s - This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day).

Average Snow Cover  $> 20$  mm - This column contains the total average fraction of time that snow cover on the field which is greater than 20 mm in depth (mm or inches).

#### ***Average Biomass Surface Conditions on Date***

##### *Crop Vegetation (Live)*

Canopy Cover - This column contains the fraction of live crop biomass cover (vertical view) at the period end, averaged over the simulation years for the period listed (fraction).

Effective Standing Silhouette - Effective standing silhouette is the standing

silhouette area index of live plants expressed on a fraction basis. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. These are values at the period end averaged over the simulation years in each rotation year.

**Above Ground Mass** - This column contains the total live crop biomass, above ground, at the period end, averaged over the simulation years for the period listed (kg/m<sup>2</sup> or lbs/acre).

*Crop Residue (Dead)*

**Flat Cover** - This column contains the amount of flat dead cover on the soil surface, expressed as a fraction. These are values at the period end averaged over the simulation years in each rotation year (fraction).

**Effective Standing Silhouette** - Effective standing silhouette is the standing silhouette area index of dead plants expressed on a fraction basis. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. These are values at the period end averaged over the simulation years in each rotation year.

**Flat Mass** - This column contains the amount of flat dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m<sup>2</sup> or lbs/acre).

**Standing Mass** - This column contains the amount of standing dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year (kg/m<sup>2</sup> or lbs/acre).

*Live and Dead Biomass*

**Flat Cover** - This column contains the amount of flat cover from live (canopy cover) and dead (flat cover) biomass on the soil surface expressed on a fraction basis. These are values at the period end averaged over the simulation years in each rotation year (fraction).

**Standing Silhouette** - Effective standing silhouette is the standing silhouette area index of live plus dead plants. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. These are values at the period end averaged

over the simulation years in each rotation year (fraction).

Flat Mass - This column contains the amount of flat live (air dried) and dead biomass on the soil surface. These are values at the period end averaged over the simulation years in each rotation year ( $\text{kg/m}^2$  or  $\text{lbs/acre}$ ).

Standing Mass - This column contains the amount of standing live and dead biomass. These are values at the period end averaged over the simulation years in each rotation year ( $\text{kg/m}^2$  or  $\text{lbs/acre}$ ).

#### *Average Soil Surface Conditions on Date*

##### *Oriented Roughness*

Ridge Orientation - This column contains orientation of the ridges with zero degrees ( $0^\circ$ ) representing north/south ridges.

Ridge Height - This column contains the height of ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Ridge Spacing - This column contains the spacing between ridges. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

Random Roughness - This column contains the standard deviation of the soil surface random roughness. This is the value at the period end averaged over the simulation years in each rotation year (mm or inches).

##### *Aggregation*

Aggregates > 0.84 mm - This column lists the fraction of aggregates greater than 0.84 mm. Aggregates > 0.84 mm are generally considered to be non-erodible. This is the value at the period end averaged over the simulation years in each rotation year.

Aggregate Stability - This column lists aggregate stability which is the log of crushing energy of dry soil aggregates ( $\ln(\text{J/kg})$ ) and is related to abrasion resistance. This is the value at the period end averaged over the simulation years in each rotation year.

Crust Cover - This column lists the fraction of the soil surface that is crusted. This is the value at the period end averaged over the simulation years in each rotation year.

year.

The **rows** in the Output Details table vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation.

Each year of the rotation has output displayed for the two week periods as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year.

The last row in the output form contains the average annual values for the complete crop rotation.

The remaining menu list items on the Detail Reports screen follow and are generally a subset of the Output Detail menu option described above.


#### Field Loss (summary)

The Field Loss summary report displays average soil loss by rotation year and for the entire simulation run. The values displayed include: Average Total Gross Soil Loss which is the average erosion within the field; Net Average Total which is the average total net loss from the field; Net Average Creep/Salt which is the average creep plus saltation net loss from the field; Net Average Suspension which is the average suspension net loss from the field; and Net Average PM10 which is the average PM10 net loss from the field.


#### Field Loss (details)

The Field Loss detailed report displays average soil loss by period, by rotation year, and for the entire simulation run. The values displayed include: Average Total Gross Soil Loss which is the average erosion within the field; Net Average Total which is the average total net loss from the field; Net Average Creep/Salt which is the average creep plus saltation net loss from the field; Net Average Suspension which is the average suspension net loss from the field; and Net Average PM10 which is the average PM10 net loss from the field.

#### Boundary Loss (summary)

The Boundary Loss summary report displays the average mass passing each field boundary (kg/m or tons/1000 ft) in the direction indicated . These parameters are reported for each rotation year and for the simulation run. The columns labeled 'Creep + Saltation' contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction. The Suspension columns contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction. The PM10 columns contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction.

Boundary Loss (details)

The Boundary Loss detailed report displays the average (by period, rotation year, and simulation run) mass passing each field boundary (kg/m or tons/1000 ft) in the direction indicated . These parameters are reported by period, for each rotation year, and for the simulation run. The columns labeled 'Creep + Saltation' contain the mass per unit boundary length of creep plus saltation size material which passed the field boundary for each direction. The Suspension columns contain the mass per unit boundary length of suspension size material which passed the field boundary for each direction. The PM10 columns contain the mass per unit boundary length of PM10 size material which passed the field boundary for each direction.

Within-Field Erosion (summary)

The Within-Field Erosion summary report displays information for various types of erosion activity by rotation year and for the simulation run. These activities include amounts as well as area and fraction of the field which had saltation emission and deposition. In addition high flux and sheltered area and fraction of the field are given. The high flux region is that area which is near transport capacity. A sheltered area is one that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately downwind of barriers. This information is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Within-Field Erosion (details)

The Within-Field Erosion detailed report displays information for various types of erosion activity by period, by rotation year and for the simulation run. These activities include amounts as well as area and fraction of the field which had saltation emission and deposition. In addition high flux and sheltered area and fraction of the field are given. The high flux region is that area that is near transport capacity. A sheltered area is one that had no saltation or suspension material being emitted. Sheltered areas are typically those immediately downwind of barriers. This information is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

Erosion (summary)

The erosion summary report displays all of the information available on erosion contained in the sections above labeled Field Loss (summary), Boundary Loss (summary), and Within-

Field Loss (summary).

#### Erosion (details)

The erosion detailed report displays all of the information available on erosion contained in the sections above labeled Field Loss (details), Boundary Loss (details), and Within-Field Loss (details).

#### Weather (summary)

The weather summary report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported for each rotation year and for the simulation run.

#### Weather (details)

The weather detailed report displays average total precipitation, the average wind energy for winds greater than 8 m/s (erosive winds), and average fraction of time that snow cover on the field which is greater than 20 mm. These parameters are reported by period, for each rotation year and for the simulation run.

#### Crop (details)

The crop report displays average live above ground biomass conditions that existed on the end date for the period reported. The conditions displayed includes canopy cover, effective standing silhouette, and above ground mass. Canopy cover is the fraction of live crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of live plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Above ground mass is the total above ground biomass.

#### Residue (details)

The residue report displays average dead above ground biomass conditions that existed on the end date for the period reported. The conditions displayed includes flat cover, effective standing silhouette, flat mass, and standing mass. Flat cover is the fraction of dead crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of dead plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Flat mass is the above ground biomass that is lying flat on the soil surface. Standing mass is the above ground biomass that is in a standing or upright position on the soil surface.

#### Biomass (details)

The biomass report displays average live plus dead above ground biomass conditions that

existed on the end date for the period reported. The conditions displayed includes flat cover, effective standing silhouette, flat mass, and standing mass. Flat cover is the fraction of live plus dead crop biomass cover from a vertical view. Effective standing silhouette is the standing silhouette area index of live plus dead plants. These values are standing silhouette area per area of soil surface expressed as a fraction. If the plants are planted in the furrow as opposed to the ridge top, the index is adjusted (down) to have less of an effect on the wind. Flat mass is the above ground biomass that is lying flat on the soil surface. Standing mass is the above ground biomass that is in a standing or upright position on the soil surface.

#### Soil Surface (details)





The soil surface report displays average soil conditions at the surface that existed on the end date for the period reported. The conditions displayed includes ridge orientation, ridge height, ridge spacing, random roughness, aggregates greater than 0.84 mm, aggregate stability, and crust cover. Ridge orientation is the orientation of the ridges with zero degrees (0°) representing north/south ridges. Random roughness is the standard deviation of the soil surface roughness height. Aggregates greater than 0.84 mm are expressed as a fraction and are those aggregates generally considered to be non-erodible. Aggregate stability is the log of crushing energy of dry soil aggregates (ln(J/kg)).

#### Surface Conditions (details)

The surface conditions detailed report displays all of the information available on the field surface contained in the sections above labeled Crop, Residue, Biomass, and Soil Surface.

### **Raw Output**

The Raw Output report screen provides a means of accessing output files of WEPS. A list of selectable output files are available on the dropdown list labeled “Select file to display”. These files are generally for advanced users and model developers. For more information on accessing and interpreting the raw output files, contact WERU.

A button bar is included at the top of the Raw Output screen which allows the user to close the window  , print the opened file  , open general help for WEPS  , and use the context help  .





# USING WEPS IN CONSERVATION PLANNING





### Interpreting Outputs

Interpreting outputs of WEPS is an important part of controlling wind erosion through conservation planning. By observing how the soil loss is affected by weather and field conditions, the management operations can be adjusted to reduce soil loss. In developing new conservation plans, the user should build or modify several different scenarios and compare outputs to determine the best management to control wind erosion. Because of runtime issues, it is recommended that, for early comparisons, no more than five rotations cycles be used for a simulation. This will allow relative soil loss values for comparisons. Once one or two scenarios are selected, more rotation cycles are recommended for more accurate erosion loss estimates. The number of erosion cycles can be set by selecting “Configuration” then “WEPS Developers Options” menus on the main screen.

The following section outlines the content of the “Output Details” screen.

#### Date

This column contains the start and end date of the period for which the row information is reported (start day-end day month rotation year). Items in each row represent values from the end of the previous period to the current date. The date column, along with soil loss, will indicate which periods have the greatest wind erosion and are thus in need of changes of management to control wind erosion.

The **rows** in the Output Details screen vary depending on the number of cropping years in the rotation and the number of management operations in each year of the rotation. Each year of the rotation has output displayed for the first two weeks and the 15<sup>th</sup> to the last day of each month as well as for each management operation date. This output allows the user to view the erosion and other output for each year of the rotation. At the end of each year in the rotation is a row which contains the average annual value for that rotation year. The last row in the output form contains the average annual values for the complete crop rotation.

#### Operation

This column contains the management operation which occurred on the specified date. It is the management operation or the date of operation which most users will modify to affect field conditions and thus wind erosion.

#### Crop

This column lists any crops planted on the date shown. Crop is obviously another choice which the land manager may change to control wind erosion.

#### Wind Erosion

The Wind Erosion columns provide a summary of all the wind erosion soil loss for the simulation run. The numbers in these columns are those that the user will try to affect by

adjusting management dates and operations. If an erosion event occurred but values generated by the model are too small to be displayed on the output table (e.g.  $< 0.001 \text{ kg/m}^2$ ), then the amount is listed as “trace”. If amounts are too large to be accurately displayed then the amount is listed simply as greater than (i.e.,  $>$ ) a specified amount. In these cases erosion amounts are so large that they are generally unacceptable.


#### Average Total Gross Soil Loss

This column contains the gross erosion within the field, averaged across the field as well as averaged over the number of simulation years in each rotation year ( $\text{kg/m}^2$  or tons/acre).

#### Net Soil Loss from Field

These columns contain net soil loss from the field averaged over the number of simulation years in each rotation year ( $\text{kg/m}^2$  or tons/acre). Some deposition within a field can occur especially when barriers are present downwind. Net soil loss is the amount of gross loss minus deposition. Total is the average total net loss from the field; Creep/Sal is the average creep plus saltation net loss from the field; Susp is the average suspension net loss from the field; and PM10 is the average PM10 net loss from the field.

#### **Mass Passing Indicated Field Boundary**

These columns  contain the mass per unit length of various sized material which passed the field boundary for each direction ( $\text{kg/m}$  or tons/1000 ft). This information is useful in determining how much material is leaving the field in each direction. For the creep/saltation size, the material will most likely be deposited on the field boundary such as a stream, fence, ditch, or road. If deposited in a ditch, subsequent rainfall may wash the material in to waterways where it can affect water quality. If deposited on a roadway, the roadway will likely need to be cleared. For suspension and PM10 sizes, the material may travel great distances affecting air quality. The material passing each boundary may indicate that barriers may be needed on the opposite or upwind side of the field to control wind erosion. The direction of soil loss may also indicate a needed change in direction of tillage.

#### **Within Field Wind Erosion Activity**

The information in these columns is useful in determining how much of the field is actively eroding and how much is not, which may impact what control measures, if any should be applied and where. This information is also useful in understanding how much of the field is actively eroding and thus may be causing plant or soil damage or how much is subject to burial. Finally, this information is useful in understanding how much of the field is contributing to overall (net) field loss.

#### **Weather**

The Weather columns provide a summary of some of the weather information for the simulation run and help the user understand which periods are erosive and why.

Average Total Precip.

This column contains the total precipitation for the period averaged over the simulation years in each year of the crop rotation (mm or inches). This section is useful in determining how precipitation amounts may be affecting biomass production and roughness decay.

Average Wind Energy > 8m/s

This column contains the average daily wind energy for the period for winds greater than 8 m/s, averaged over the simulation years in each year of the crop rotation (KJ/day). This will indicate which periods have the most erosive winds.

Average Snow Cover

If the field is covered with snow, it will be non-erodible.

**Average Biomass Surface Conditions on Date**

The Average Surface Biomass Conditions on Date columns provide a summary of average surface conditions including crop biomass and soil roughness for the simulation run.

Crop Vegetation (Live)

These columns provide information on the structural configuration of live growing biomass. By observing the canopy cover, the standing silhouette area index, and the above ground mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

Crop Residue (Dead)

These columns provide information on the structural configuration of dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient residue cover to control wind erosion.

Live and Dead Biomass

These columns provide information on the structural configuration of both the live growing biomass and the dead biomass or residue. By observing the flat cover, the standing silhouette area index, the flat mass, and the standing mass, the user can determine which periods are not providing sufficient cover to control wind erosion.

**Average Soil Surface Conditions on Date**Roughness

For cropping systems that do not produce sufficient residue for erosion control (e.g., cotton), roughness management is often used to reduce wind friction velocity at the soil surface. This reduces the amount of soil detachment and transport and increases deposition and thus soil loss.

*Ridge Orientation*

These columns refer to regularly spaced roughness elements caused by tillage implements such as ridges, furrows and dikes. Ridge orientation, width, and height may be adjusted for periods of high soil loss to determine its effect on wind erosion. The user can also follow the roughness decay over time as result of rainfall.

*Random Roughness*

This column contains the standard deviation of the soil surface random roughness. This is the value at the period end, averaged over the simulation years in each rotation year (inches or mm). Random roughness is primarily the result of aggregate size distribution but is also affected by various types of tillage tools. Random roughness values for typical management operations are listed in Table 5.1. Photographs (Figs. 5.1 - 5.9) can be used as a guide to determine relative random roughness values.

Aggregation

Soil aggregate size and aggregate dry stability affect erosion by wind. Soil aggregates greater than 0.84 mm in diameter are generally considered to be non-erodible. Dry stability is related to abrasion resistance where harder, more stable aggregates result in a lower erodibility of the soil.

Crust Cover

A soil crust will resist abrasion and erosion more than a loose finely divides soil surface. Generally, the more of the surface is covered by a crust, the lower the erosion that occurs. Crust are transient and generally represent a degraded soil quality and therefore should not be relied upon to control erosion by wind. However a high crust cover may explain a lower erosion amount that would normally be expected.

**Table 5.1.** Random roughness values for typical management operations based on a silt loam soil (Ag. Handbook 537).

Field Operation	Random Roughness (inches)	Field Operation	Random Roughness (inches)
Chisel, sweeps	1.2	Fertilizer applicator, anhydrous knife	0.6
Chisel, straight point	1.5	Harrow, spike	0.4
Chisel, twisted shovels	1.9	Harrow, tine	0.4
Cultivator, field	0.7	Lister	0.8
Cultivator, row	0.7	Manure injector	1.5
Cultivator, ridge till	0.7	Moldboard plow	1.9
Disk, 1-way	1.2	Mulch threader	0.4
Disk, heavy plowing	1.9	Planter, no-till	0.4
Disk, Tandem	0.8	Planter, row	0.4
Drill, double disk	0.4	Rodweeder	0.4
Drill, deep furrow	0.5	Rotary hoe	0.4
Drill, no-till	0.4	Vee ripper	1.2
Drill, no-till into sod	0.3		



**Figure 5.1.** Random roughness of 0.25 inches (6 mm).





**Figure 5.2.** Random roughness of 0.40 inches (10 mm).



**Figure 5.3.** Random roughness of 0.65 inches (17 mm).





**Figure 5.4.** Random roughness of 0.75 inches (19 mm).



**Figure 5.5.** Random roughness of 0.85 inches (22 mm).





**Figure 5.6.** Random roughness of 1.05 inches (27 mm).



**Figure 5.7.** Random roughness of 1.60 inches (41 mm).





**Figure 5.8.** Random roughness of 1.70 inches (43 mm).

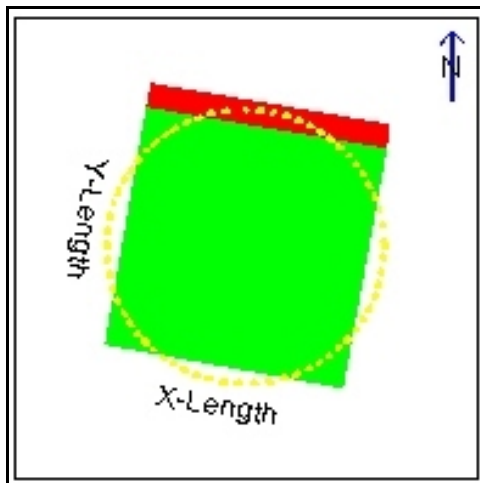


**Figure 5.9.** Random roughness of 2.15 inches (55 mm).



### Special Field Configurations

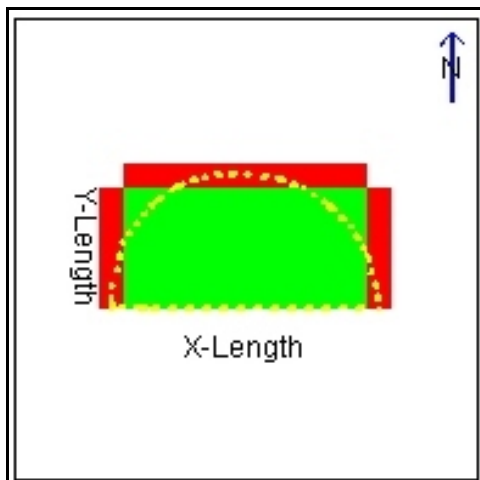
Although WEPS 1.0 is designed to simulate rectangular field shapes, special field configurations such as circles or strip cropping can be simulated. By manipulating the field shape to represent a field with the same area and rotating the field along with any barriers many field shapes can be approximated.



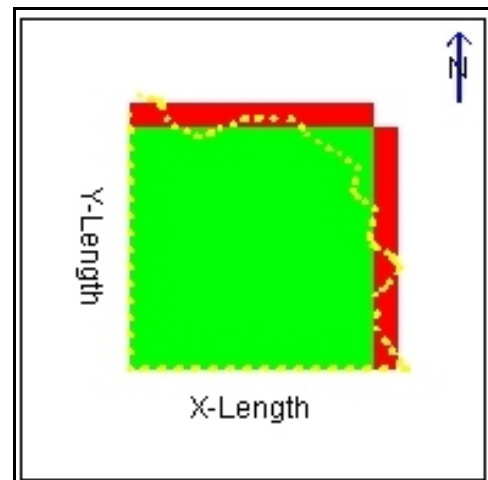
**Figure 5.10.** Example of using a square field shape to approximate a circle.

A circular field can be simulated using a square field of equal area. Figure 5.11 illustrates how this would be visualized. Note that the yellow dashed circle is shown here to illustrate the circular field and cannot be placed over the field within the WEPS 1.0 interface. For such fields, barriers should be added and the field rotated to best simulate the actual field configuration.

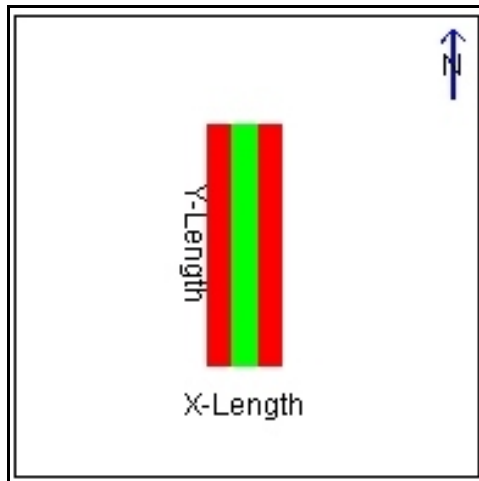
Other field shapes can also be simulated with WEPS 1.0. A half circle can be represented with a rectangle as illustrated in Figure 5.11. Figure 5.11 illustrates how an irregular field may be visualized for a field along a stream with filter strips along the North and East sides.



**Figure 5.11.** Example of using a rectangular field to simulate a half circle.



**Figure 5.12.** Example of using a square field to simulate a field with a stream with buffers along two sides.



Fields managed for wind erosion control by strip cropping (non-contour, linear) are simulated with each strip of unique management as an individual rectangular field and the erosion losses for each strip summed. For fields managed with grass strips, the fields are simulated as individual strips with the appropriate barriers on either side. The erosion loss from one section of the field is then multiplied by the number of strips to obtain the soil loss for the entire field. Figure 5.12 illustrates a field layout for simulating strip cropping or grass barriers.

**Figure 5.13.** Example field layout for simulating strip cropping or grass barriers.

WEPS 1.0 only allows tillage in one direction (e.g., Northwest/Southeast). In other words, multiple tillage directions such as where the operator tills parallel to each border of the field or a circular tillage pattern, cannot be simulated with WEPS 1.0. Observing the effects that tillage direction may have for the particular simulation may illustrate the need to alter tillage directions in the actual field to control wind erosion.

**Using Barriers for Erosion Control in WEPS**

Wind barriers of perennial or annual plants are often used for wind erosion control. Barriers have the effect of reducing field width by reducing wind velocity and abrasion of the downwind immobile clods, crusts, and residues along the prevailing wind erosion direction.

Perennial barriers are put in place for erosion control year after year. They provide protection the entire year, even in the dry years that crop residues are absent, when soil aggregation is limited (no clods), or when ridges created by tillage implements are fragile become ineffective in severe wind storms. Annual barriers are used primarily to provide temporary protection during the most critical wind erosion period and can be removed and replaced every year. Artificial barriers such as snow fencing, board walls, bamboo and willow fences, earthen banks, hand-inserted straw rows, and rock walls have been used for wind erosion control, but only on a very limited basis. There is usually a very high cost in material and labor to construct these barriers and their use is generally restricted to high-value crops. They can also be used in sand dune areas to aid the initial stabilization of the areas while grass and trees are being established.

Using WEPS, we can quickly determine the field edge where the greatest amount of eroded soil is leaving the field. In most cases, a field windbreak would be most effective on the upwind side of this field. Ideally, a tract of land where windbreaks are installed will be equally stripped, thus shorting the width of the field along the most erosive winds. So, along with estimating erosion with a windbreak, we will also be resizing the field.

The field will be resized down to the strip width that a producer agrees with or to other widths for demonstration purposes. We can change the field size by just typing in the field dimensions. See the section “Describing the Field and Barriers” for more details on adding and modifying field barriers.





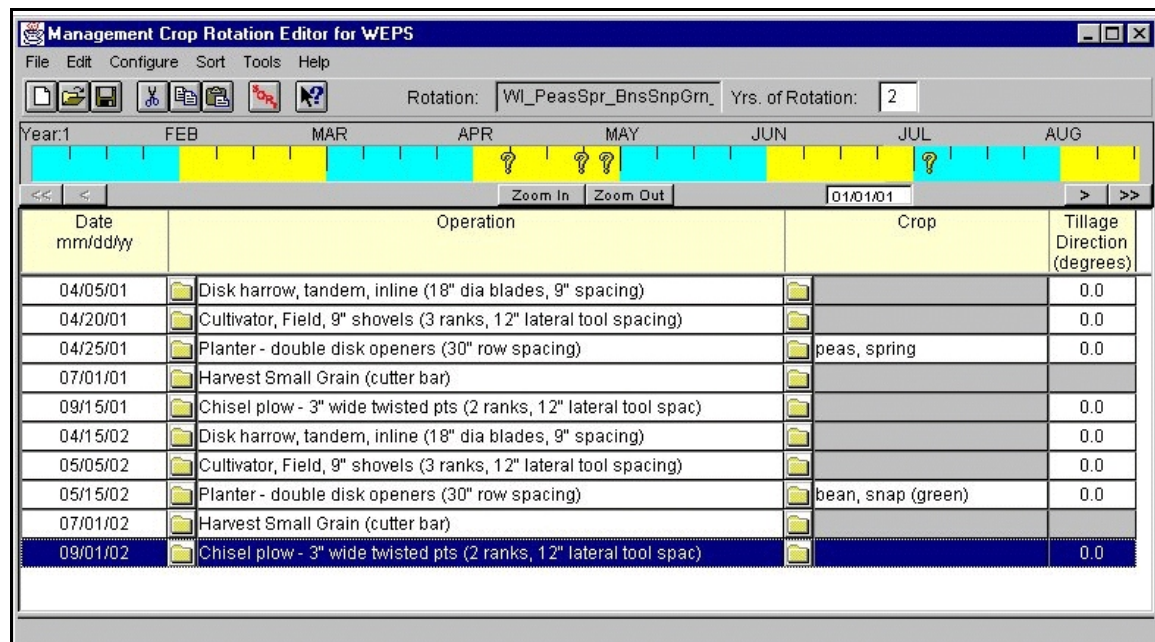
## EVALUATING WIND EROSION PROBLEMS WITH WEPS

This is an example problem that we will use to evaluate a wind erosion problem in the Stevens Point area of central Wisconsin.

The scenario for the problem is:

- The farm is located near Stevens Point, WI in Portage County.
- The Cligen Station is Stevens Point and the Windgen Station is Wausau.
- The Soil Map Unit used in the evaluation is MfB-Mecan-100-LS.
- The original two year Cropping system is Spring Peas and Snap Beans (green).
- The field size is 2640' X2640', 160 acres.
- The WEPS evaluation of the cropping system will be run for 20 rotation cycles.

Below (Fig. 5.14) is the two year rotation of Spring Peas and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the two year rotation, it has been decided to set up a three year rotation to include early potatoes.



**Figure 5.14.** A two year rotation of spring peas and snap beans (green).

When we expand the two year rotation to include Early Potatoes, we can add the operations, dates of operation, and the potato crop directly to the two year rotation or we can build a separate template for Early Potatoes and then insert the new template in the rotation. We recommend the option of building a separate template for Early Potatoes and then inserting

it into the existing rotation. The new single year template for Early Potatoes begins when in MCREW by clicking on “File”, then click on “New” and this will drop a clean MCREW screen down. With the clean MCREW screen we enter dates and operations as instructed in the earlier section on MCREW (Chapter 4). The single year cropping scenario for early Potatoes should be saved as a template. We will save it by clicking on “file” and then “save as a template”. The list of management files will drop down and we will go to the window on the bottom of the list called “File name”, remove the \* and then type in the name single crop scenario we are saving. To finalize we click “Save” on the bottom right of the window. We now have a new single year template and will add it to our two year rotation.

Below (Fig. 5.15) is the three year rotation of Early Potatoes, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the three year rotation, it has been decided to set up a four year rotation to include Sweet Corn.

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/05/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
04/20/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/25/01	Planter - double disk openers (30" row spacing)	peas, spring	0.0
07/01/01	Harvest Small Grain (cutter bar)		
09/15/01	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/05/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
05/15/02	Planter - double disk openers (30" row spacing)	bean, snap (green)	0.0
07/01/02	Harvest Small Grain (cutter bar)		
09/01/02	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/01/03	Disk harrow, tandem, double offset (20" dia blades, 11" blade spac)		0.0
04/15/03	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/20/03	Planter - double disk openers (30" row spacing)	potato, early	0.0
05/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
06/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
07/05/03	Defoliate (Spray) crop		
07/20/03	Harvest Underground		0.0
09/01/03	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0

**Figure 5.15.** A three year rotation of early potatoes, spring peas, and snap beans (green).



When we expand the three year rotation to include Sweet Corn, we again, can add the operations, dates of operation, and the Sweet Corn crop directly to the three year rotation or we can build a separate template for Sweet Corn and insert the new template into the rotation. We again recommend the option of building a separate template for Sweet Corn and insert it into the existing rotation. Follow the same instruction used above for Early Potatoes to add Sweet Corn.

Below (Fig. 5.16) is the four year rotation of Early Potatoes, Sweet Corn, Spring Peas, and Snap Beans (green) including the dates and field operations. Following evaluation of the erosion rates on the four year rotation, it has been found acceptable.

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/01/01	Disk harrow, tandem, double offset (20" dia blades, 11" blade spac)		0.0
04/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/20/01	Planter - double disk openers (30" row spacing)	potato, early	0.0
05/10/01	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
06/10/01	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
07/05/01	Defoliate (Spray) crop		
07/20/01	Harvest Underground		0.0
09/01/01	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0
05/10/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/25/02	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
06/01/02	Planter - double disk openers (30" row spacing)	corn, sweet	0.0
08/31/02	Harvest (cut or break stalks high)		
09/15/02	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/05/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
04/20/03	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
04/25/03	Planter - double disk openers (30" row spacing)	peas, spring	0.0
07/01/03	Harvest Small Grain (cutter bar)		
09/15/03	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0
04/15/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
05/05/04	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
05/15/04	Planter - double disk openers (30" row spacing)	bean, snap (green)	0.0
07/01/04	Harvest Small Grain (cutter bar)		
09/01/04	Chisel plow - 3" wide twisted pts (2 ranks, 12" lateral tool spac)		0.0

**Figure 5.16.** A four year rotation of early potatoes, sweet corn, spring peas, and snap beans (green).



## EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Marlboro and Charleston Counties, South Carolina.

### Situation 1 -2 year rotation developing into a 4 year rotation

- The scenario for the problem is:
- The farm is located in **Marlboro County, SC**
- The **Cligen station is McColl** and the **Windgen station is Eastover**
- The **Soil Map Unit** used in the evaluation is: **NoA - Norfolk LS**
- The original 2 year cropping system is **Cotton and Watermelons**
- The field size is: **x axis - 3500 ft.; y axis - 2000 ft.**
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is a 2 year rotation of **upland cotton** and **watermelons**, including the dates and field operations (Fig. 5.17).

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/20/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/25/01	Lister - 40" row spacing (8" ridge height)		-45
05/05/01	Planter - double disk openers (40" row spacing)	cotton, picker	-45
05/25/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/10/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/27/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45.0
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
08/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0

**Figure 5.17.** A two year rotation of upland cotton and watermelons.

**\*Cotton, picker** (700 lbs. lint yield)

04/10/01 Tandem disk, 18" diameter blades)

04/20/01 Tandem disk, 18" diameter blades)

04/25/01 Lister - 40" row spacing (8" ridge height)

05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**

05/25/01 Row crop Cultivator (40" inch rows)

06/10/01 Row crop Cultivator (40" inch rows)

06/27/01 Row crop Cultivator (40" inch rows)

09/15/01 Defoliate

10/01/01 Harvest crop (leave stalks undisturbed)

11/01/01 Shred stalks

**\* Watermelons**

03/01/02 Tandem disk, 18" diameter blades)

03/15/02 Chisel plow - 2" wide straight pts.

03/20/02 Tandem disk, 18" diameter blades)

04/04/02 Planter - double disk opener (48" rows) - **Watermelons**

05/05/02 Row crop Cultivator (48" inch rows)

05/20/02 Row crop Cultivator (48" inch rows)

07/10/02 Harvest crop

When we expand the 2 year rotation to include Corn, 130 day, we can add the operations, dates of operation, and the 130 day Corn crop directly to the 2 year rotation or we can build a separate template for Corn, 130 day. The new template can then be inserted into the rotation. We recommend the option of building the separate template for 130 day Corn and the template will then be available the next time you are building a rotation that includes that crop.

Below is the 3 year rotation of Cotton, picker; Watermelons; and 130 day Corn, including the field operations and the dates they were performed (Fig. 5.18).

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
04/20/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/25/01	Lister - 40" row spacing (8" ridge height)		-45
05/05/01	Planter - double disk openers (40" row spacing)	cotton, picker	-45
05/25/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/10/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
06/27/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		-45
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45.0
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45.0
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
10/25/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
11/14/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
11/15/02	Drill - double disk openers (8" row spacing)	wheat, winter, soft white	0.0
06/05/03	Harvest Small Grain (cutter bar)		
06/06/03	Burn Residue		
06/07/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
06/08/03	Planter - double disk openers (30" row spacing)	soybean, MG V, 130 days	0.0
07/24/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
08/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		0.0
10/31/03	Harvest Soybeans (cutter bar)		
11/15/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0

**Figure 5.18.** A three year rotation of picker cotton, watermelons, and 130 day corn.

**\*Cotton, picker (700 lbs. lint yield)**

04/10/01 Tandem disk, 18" diameter blades)

04/20/01 Tandem disk, 18" diameter blades)

04/25/01 Lister - 40" row spacing (8" ridge height)

05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**

05/25/01 Row crop Cultivator (40" inch rows)

06/10/01 Row crop Cultivator (40" inch rows)

06/27/01 Row crop Cultivator (40" inch rows)

09/15/01 Defoliate  
10/01/01 Harvest crop (leave stalks undisturbed)  
11/01/01 shred stalks  
11/15/01 Tandem disk, 18" diameter blades)

**\*Watermelons**

03/15/02 Chisel plow - 2" wide straight pts.  
03/20/02 Tandem disk, 18" diameter blades)  
04/04/02 Planter - double disk opener (48" rows) - **Watermelons**  
05/05/02 Row crop Cultivator (48" inch rows)  
05/20/02 Row crop Cultivator (48" inch rows)  
07/10/02 Harvest crop  
08/01/02 Tandem disk, 18" diameter blades)

**\*Wheat, winter, soft white**

10/15/02 Tandem disk, 18" diameter blades)  
11/14/02 Tandem Disk 18" diameter blades)  
11/15/02 Drill - double disk openers (8" rows)  
06/05/03 Harvest small grain (cutter bar) – **Wheat, winter, soft white**  
06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

**\*Soybeans**

06/07/03 Tandem disk, 18" blades  
06/08/03 Plant, double disk openers - 30" rows - **Soybeans**  
07/24/03 Row crop Cultivator (30" rows)  
08/10/03 Row crop Cultivator (30" rows)  
10/31/03 Harvest Soybeans, (cutter bar)  
11/20/03 Tandem disk, 18" blades



Below is the 4 year rotation of picker cotton, watermelons, wheat-soybeans (double cropped); and corn, 130 day; including the field operations and the dates they were performed (Fig. 5.19).

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
09/15/01	Defoliate (Spray) crop		
09/15/01	Harvest Crop (leave stalks undisturbed)		
11/01/01	Shred stalks		
11/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/15/02	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		-45
03/20/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
04/04/02	Planter - double disk openers (30" row spacing)	watermelon, direct seeded	-45
05/05/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/20/02	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
07/10/02	Harvest Crop (leave stalks undisturbed)		
10/25/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
11/14/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
11/15/02	Drill - double disk openers (8" row spacing)	wheat, winter, soft white	-45
06/05/03	Harvest Small Grain (cutter bar)		
06/06/03	Burn Residue		
06/07/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
06/08/03	Planter - double disk openers (30" row spacing)	soybean, MG V, 130 days	-45
07/24/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
08/10/03	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
10/31/03	Harvest Soybeans (cutter bar)		
11/15/03	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/15/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45
03/31/04	Planter - double disk openers (30" row spacing)	corn, grain, 130	-45
04/30/04	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
05/31/04	Cultivator, row crop, 30" row spacing (3" ridge ht)		-45
09/15/04	Harvest (cut or break stalks high)		
09/30/04	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		-45

**Figure 5.19.** A four year rotation of picker cotton, watermelons, wheat-soybeans (double cropped), and corn, 130 day.

**\*Cotton, picker(700 lbs. lint yield)**

04/10/01 Tandem disk, 18" diameter blades)

04/20/01 Tandem disk, 18" diameter blades)

04/25/01 Lister - 40" row spacing (8" ridge height)

05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**

05/25/01 Row crop Cultivator (40" inch rows)

06/10/01 Row crop Cultivator (40" inch rows)

06/27/01 Row crop Cultivator (40" inch rows)

09/15/01 Defoliate

10/01/01 Harvest crop (leave stalks undisturbed)

11/01/01 shred stalks

11/15/01 Tandem disk, 18" diameter blades)

**\*Watermelons**

03/01/02 Chisel plow - 2" wide straight pts.

03/20/02 Tandem disk, 18" diameter blades)

04/04/02 Planter - double disk opener (48" rows) - **Watermelons**

05/05/02 Row crop Cultivator (48" inch rows)

05/20/02 Row crop Cultivator (48" inch rows)

07/10/02 Harvest crop

08/01/02 Tandem disk, 18" diameter blades)

10/01/02 Tandem disk, 18" diameter blades)

**\*Wheat, winter, soft white**

11/14/02 Tandem Disk 18" diameter blades)

11/15/02 Drill - double disk openers (8" rows)

06/05/03 Harvest small grain (cutter bar) – **Wheat, winter, soft white**

06/06/03 Burn residue (approximately 800 lbs of residue/acre left on surface)

**\*Soybeans**

06/07/03 Tandem disk, 18" blades

06/07/03 Plant, double disk openers - 30" rows - **Soybeans**

07/24/03 Row crop Cultivator (30" rows)

08/10/03 Row crop Cultivator (30" rows)

10/31/03 Harvest Soybeans (Cutter bar)

11/20/03 Tandem disk, 18" blades

**\*Corn, 130 day**

03/15/04 Tandem disk, 18" diameter blades)

04/01/04 Plant, double disk openers - 30" rows - **Corn**

05/01/04 Row crop Cultivator (30" rows)

05/21/04 Row crop Cultivator (30" rows)

09/15/04 Harvest

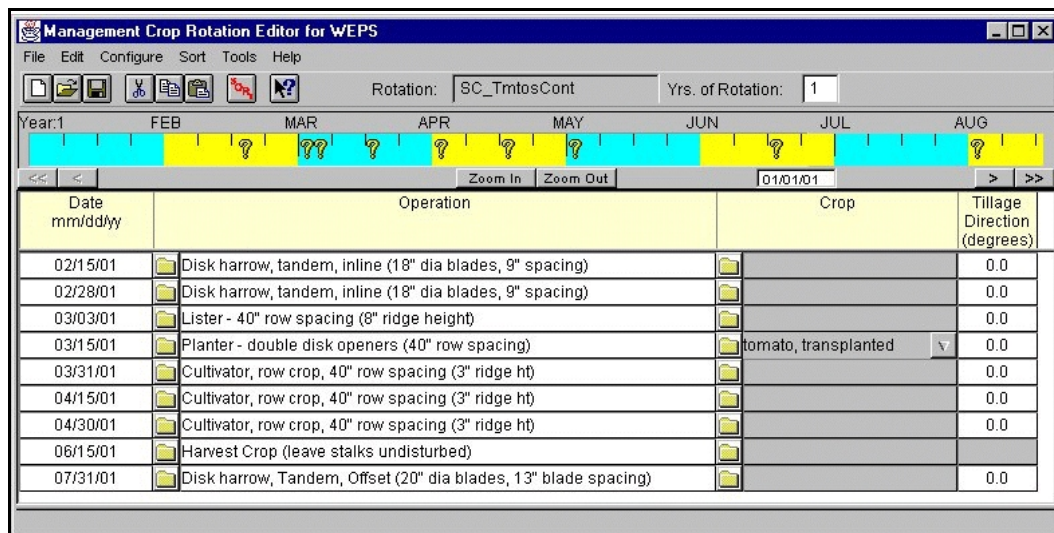
10/15/04 Tandem disk, 18" diameter blades)

**Situation 2 - Continuous Tomatoes**

This is another example problem that we will use to evaluate a wind erosion problem in Charleston County, SC.

- The scenario for the problem is:
- The farm is located in **Charleston County, SC**
- The **Cligen station is Charleston** and the **Windgen station is Charleston**
- The **Soil Map Unit** used in the evaluation is: **NoA - Norfolk LS**
- The continuous cropping system is **Tomatoes**
- The **field size** is: x axis - 2000 ft.; y axis - 1500 ft.
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of Tomatoes, including the dates and field operations (Fig. 5.20).



**Figure 5.20.** A one year rotation of tomatoes.

**\*Tomatoes**

- 02/15/01 Tandem disk, 18" diameter blades)
- 03/01/01 Tandem disk, 18" diameter blades)
- 03/03/01 Lister - 48" row spacing (8" ridge height)
- 03/12/01 transplant - **Tomatoes**
- 04/01/01 Row crop Cultivator (48" inch rows)

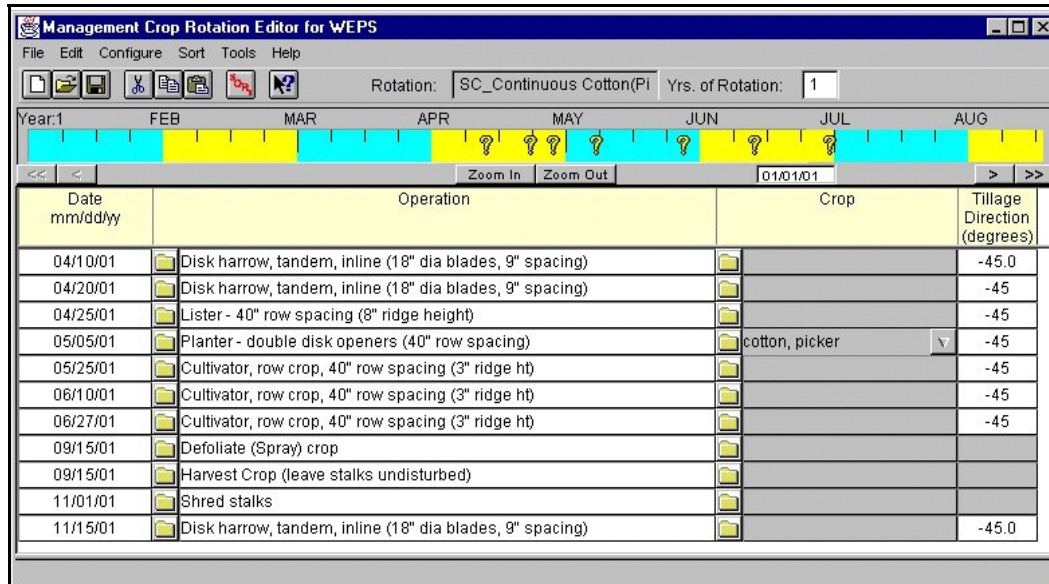
04/15/01 Row crop Cultivator (48" inch rows)  
05/01/01 Row crop Cultivator (48" inch rows  
06/15/01 Harvest crop  
07/25/01 Tandem disk, 18" diameter blades)

### **Situation 3 - Continuous Cotton**

This is an example problem that we will use to evaluate a wind erosion problem in Marlboro County, SC.

- The scenario for the problem is:
- The farm is located in **Marlboro County, SC**
- The **Cligen station is McColl** and the **Windgen station is Florence**
- The **Soil Map Unit** used in the evaluation is: **FaB - Faceville LS**
- The continuous cropping system is **Cotton, picker**
- The **field size** is: x axis - 3500 ft.; y axis - 2000 ft.
- Orientation of field operations and rows is **-45 degrees**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- **Barriers** - Woods along the NW and NE field borders (trees w/leaves 4 rows)

Below is the 1 year rotation of **Cotton, Picker** including the dates and field operations (Fig. 5.21).



**Figure 5.21.** A one year rotation of picker cotton.

\* **Cotton, picker** (700 lbs. lint yield)

04/10/01 Tandem disk, 18" diameter blades)

04/20/01 Tandem disk, 18" diameter blades)

04/25/01 Lister - 40" row spacing (8" ridge height)

05/05/01 Planter double disk opener (40" row spacing) – **Cotton, picker**

05/25/01 Row crop Cultivator (40" inch rows)

06/10/01 Row crop Cultivator (40" inch rows)

06/27/01 Row crop Cultivator (40" inch rows)

09/15/01 Defoliate

10/01/01 Harvest crop (leave stalks undisturbed)

11/01/01 shred stalks

11/15/01 Tandem disk, 18" diameter blades)



## EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example problems that we will use to evaluate some wind erosion problems in Haakon County, South Dakota.

### Situation 1 -2 year rotation

The scenario for the problem is:

- The farm is located in **Haakon County, SD**
- The **Cligen station is Milesville** and the **Windgen station is Philip**
- The **Soil Map Unit** used in the evaluation is: **Craft Cv 85 VFSL**
- The original 2 year cropping system is **Winter Wheat-Fallow**
- The field size is: **x axis - 2600 ft.; y axis - 2600 ft.**
- Orientation of field operations and rows is – **North (0 or 360 degrees)**
- Operations are performed parallel to x axis
- The early WEPS evaluations will be run for **5 rotation cycles**
- Barriers - None

Below is the 2 year rotation of **Winter Wheat** and **Fallow**, including the dates and field operations (Fig. 5.22).

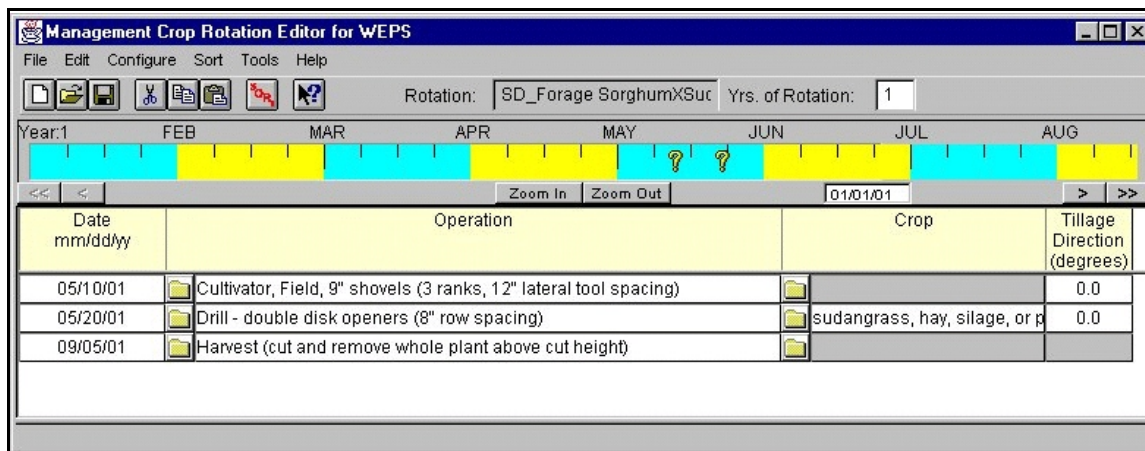
**\*Winter Wheat (32 bu. yield) – Fallow (Conventional)**

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
05/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
06/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
07/15/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
09/05/01	Cultivator, Field, 9" shovels (3 ranks, 12" lateral tool spacing)		0.0
09/15/01	Drill - hoe openers (12" row Spacing)	wheat, winter, hard	0.0
07/10/02	Harvest Small Grain (cutter bar)		
09/01/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0

**Figure 5.22.** A two year rotation of winter wheat and fallow.



When we expand the 2 year rotation to include Forage Sorghum/Sudan Grass Cross (Kane) (Fig. 5.23), we can add the operations, dates of operation, and the Kane crop directly to the 2 year rotation or we can build a separate template for Kane. The new template can then be inserted into the rotation. We recommend the option of building the separate template for Kane and the template will then be available the next time you are building a rotation that includes that crop.

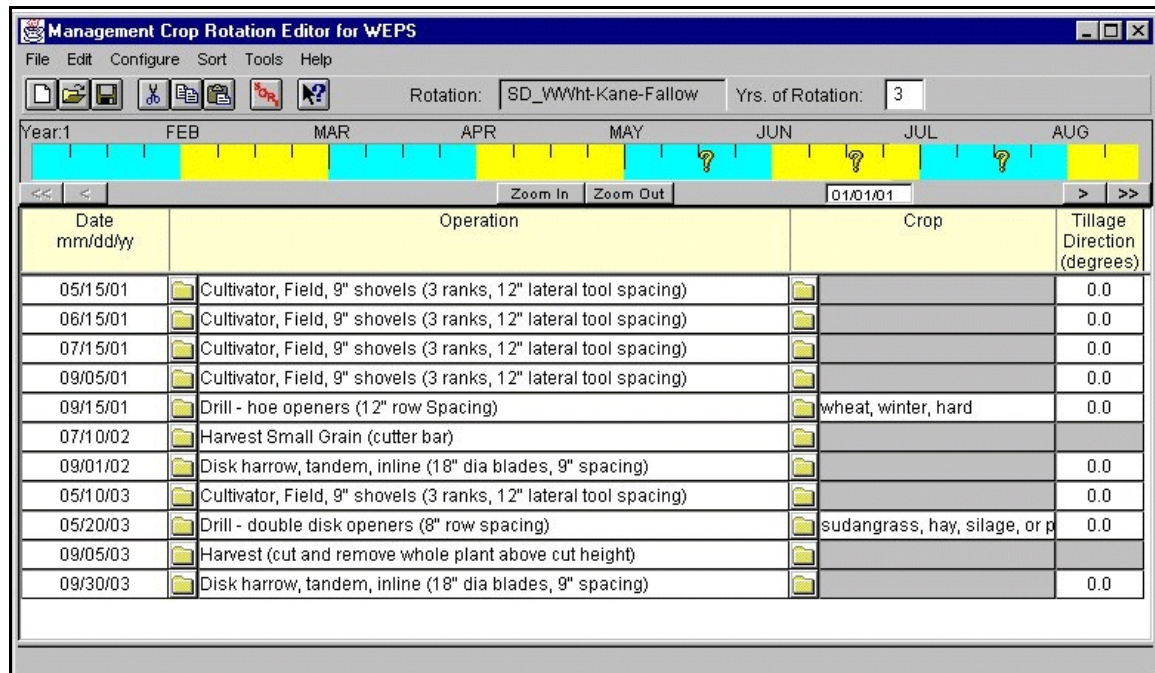


**Figure 5.23.** A one year rotation of forage sorghum/Sudan grass cross (kane).



Below is the 3 year rotation of Winter Wheat; Fallow; and Kane, including the field operations and the dates they were performed (Fig. 5.24).

**\*Winter Wheat** (32 bu. yield) – **Fallow** (Conventional) and **Kane** (~ 6000 lbs.)



**Figure 5.24.** A three year rotation of winter wheat, fallow, and kane.



## EVALUATING WIND EROSION PROBLEMS WITH WEPS

Following are some example management scenarios that we will use to evaluate a wind erosion problem in the Northwest area of Texas.

### Situation 1 – Continuous Cotton rotation

The management scenario to be evaluated is:

- The **farm** is located in **Lubbock County, TX**.
- The **Cligen Station** is Lubbock and the **Windgen Station** is Lubbock
- The **Soil Map Unit** used in the evaluation is **Amarillo\_4\_100\_LFS**
- The original Cropping system is **Continuous Cotton, stripper**
- The **field size** is 2640' X 2640' (160 acres)
- The WEPS evaluation of the cropping system will be run for **5 rotation cycles**

Below is the **Continuous Cotton** rotation including the **dates** and **field operations** (Fig. 5.25).

### Cotton (Yield of ½ Bale)

The screenshot shows the 'Management Crop Rotation Editor for WEPS' window. The 'Rotation' is set to 'TX\_Cotton,stripper' and 'Yrs. of Rotation' is '1'. The calendar view shows Year 1 from February to August. Below the calendar is a table of field operations with columns for Date (mm/dd/yy), Operation, Crop, and Tillage Direction (degrees).

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
01/01/01	Shred stalks		
02/01/01	Moldboard plow - 16" furrow slice (no moldboard attachments)		0.0
02/15/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/01/01	Bedder		0.0
05/15/01	Planter - double disk openers (40" row spacing)	cotton, stripper	0.0
06/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/01/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/15/01	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
11/01/01	Harvest Crop (leave stalks undisturbed)		

**Figure 5.25.** A continuous rotation of cotton.

**Situation 2 – Cotton\_Milo rotation**

When we expand the 1 year cotton rotation to include **Milo**, we can add the operations, dates of operations, and the **Milo** crop directly to the original **Cotton rotation** or we can build a separate template for **Milo** and then insert the new template in the rotation. We recommend the option of building a separate template for **Milo** and then inserting it into the existing **Cotton rotation**. The new **single year template** for **Milo** begins by opening **MCREW**, clicking on “**File**”, then click on “**New**” and this will drop a clean **MCREW** screen down. With the clean **MCREW** screen we just start entering dates and operations as instructed in the earlier lessons on **MCREW**. The single year cropping scenario for **Milo** should be saved as a template. Saving a template begins by clicking on “**file**” and then “**save as a template**”. The list of dot man folders and files will drop down. Here we can open a folder before saving, or we can go directly to the window on the bottom of the list called “**File name**”, remove the \* and then type in the name of the new template we are saving. To finalize we click “**Save**” on the bottom right. We now have a new single year **Milo** template and will add it to our existing **Cotton scenario**.

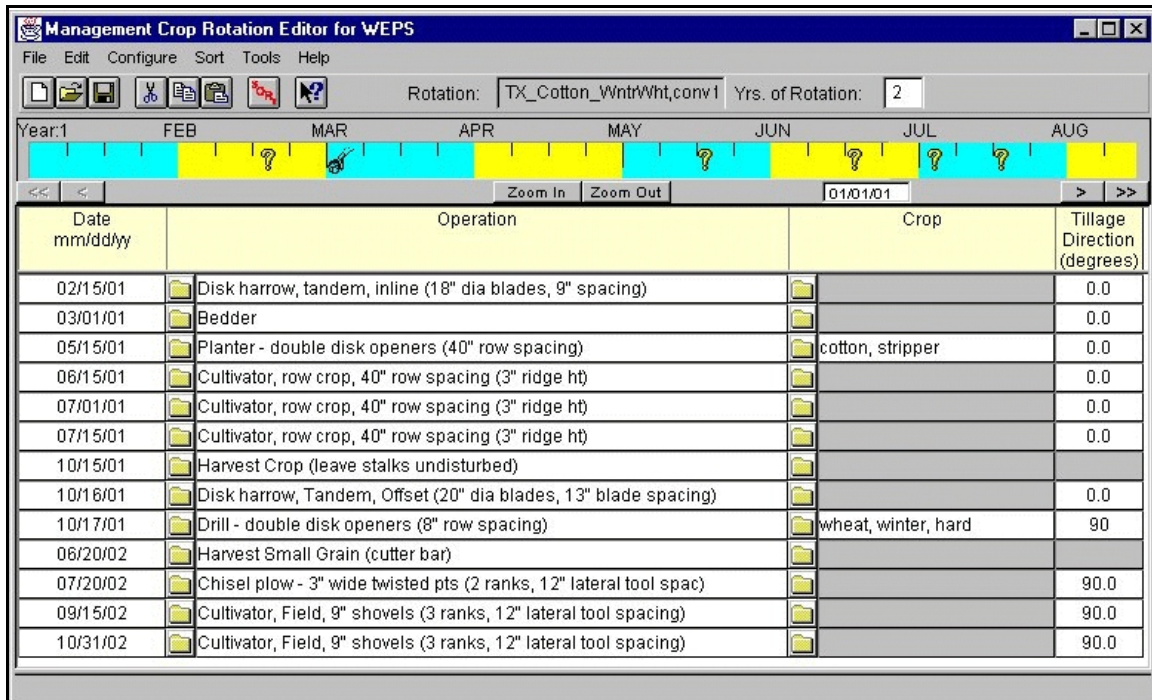
Below is the **2 year rotation of Milo\_Cotton**, including the dates and field operations (Fig. 5.26).

Date mm/dd/yy	Operation	Crop	Tillage Direction (degrees)
01/01/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
02/01/01	Chisel plow - 2" wide straight pts (2 ranks, 12" lateral tool spa)		0.0
03/01/01	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/15/01	Bedder		0.0
05/15/01	Planter - double disk openers (30" row spacing)	Milo	0.0
07/15/01	Cultivator, row crop, 30" row spacing (1" ridge ht)		0.0
10/15/01	Harvest Small Grain (cutter bar)		
01/01/02	Shred stalks		
02/01/02	Moldboard plow - 16" furrow slice (no moldboard attachments)		0.0
02/15/02	Disk harrow, tandem, inline (18" dia blades, 9" spacing)		0.0
03/01/02	Bedder		0.0
05/15/02	Planter - double disk openers (40" row spacing)	cotton, stripper	0.0
06/15/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/01/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
07/15/02	Cultivator, row crop, 40" row spacing (3" ridge ht)		0.0
11/01/02	Harvest Crop (leave stalks undisturbed)		

**Figure 5.26.** A two year rotation of milo and cotton.

**Situation 3 – Cotton\_Winter Wheat rotation**

Below is the 2 year rotation of **Cotton\_Winter Wheat** including the dates and field operations (Fig. 5.27). We recommend the option of building the rotation using separate templates of **Cotton** and **Winter Wheat**. However, once you have a template of **Cotton\_Winter Wheat**, you can use it directly from your dot man files.



**Figure 5.27.** A two year rotation of cotton and winter wheat.



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# APPENDICES







**Tutorials: Module 1****An Overview of WEPS**

Wind erosion is a serious problem on agricultural lands throughout the United States as well as the world. The ability to accurately predict soil loss by wind is necessary for conservation planning, natural resource inventories, and quantifying potential air pollution from wind blown sources.

WEPS, the Wind Erosion Prediction System, has been developed to address this problem through a multi-agency government commitment. These agencies include: the USDA Agricultural Research Service, the USDA Natural Resources Conservation Service, the US Bureau of Land Management, the US Environmental Protection Agency, the US Forest Service, the US Army Corps of Engineers, and many universities including Kansas State University in Manhattan, Kansas.

**WEQ****Wind Erosion Equation—WEQ**

$$E = f(I, K, C, L, V)$$

I - soil erodibility

K - soil ridge roughness

C - climatic factor

L - field length

V - vegetative factor

The Wind Erosion Equation or WEQ was developed by the late Dr. W. S. Chepil and co-workers beginning in 1947, and first published in 1965. WEQ represented the first, and for many years, the most widely used method for assessing the average annual soil loss by wind from agricultural fields. Due to the limited science and computational tools available at that time, it was necessary to create WEQ as an empirical functional expression where the potential average annual soil loss is a function of:

- The soil erodibility
- The soil ridge roughness
- The climate
- The unsheltered distance across a field and
- The equivalent vegetative cover

WEQ is based on science and technology that is more than 35 years old, it is empirical by attempting to model response to conditions in the field as factors, and it is not easily extrapolated to areas outside the Great Plains where it was developed.

With the advanced technology of today a significant advancement in wind erosion prediction technology is now possible and overcomes the fundamental weaknesses of WEQ. The Wind Erosion Prediction System incorporates this new technology into a user-friendly simulation model.

## **What Is WEPS?**

### **Wind Erosion Prediction System—WEPS**

Process-Based

Continuous

Daily Time-Step

Wind Erosion Model

WEPS is a process-based, continuous, daily time-step model that simulates weather, field conditions, and erosion using a simple graphical user interface. WEPS has the capability of modeling actual physical processes that are occurring in the field. As a continuous, daily, time-step model, it simulates not only the basic wind erosion processes, but also the processes that modify a soil's susceptibility to wind erosion on a daily basis. Plus, through the simulation of field barriers and varying field management practices, WEPS can accurately predict the results of these practices on soil erosion.

## **Factors Used In WEPS**

### **Where are the WEQ factors in WEPS?**

Example: Soil Erodibility - I Factor - WEQ

#### **Surface Aggregation**

- Size distribution
- Dry stability

#### **Crusted Surface**

- Cover fraction
- Stability and thickness
- Loose, erodible material on crust

Each of the WEQ factors is accounted for in WEPS. For example, the soil erodibility, or "I" factor of WEQ is accounted for in WEPS through modeling surface aggregation in terms of its size distribution and dry stability. The effects of crusted surfaces are modeled in terms of the fraction of the surface covered by crust, crust stability and thickness, and the amount of loose, erodible material on the crust.

Similarly, the K, C, L, and V factors of WEQ are accounted for in WEPS by multiple, complex physical processes.

### **Why WEPS?**

#### **Improve predictions of soil loss by wind through new technologies**

WEPS has been developed to replace the older technology of WEQ and improve the overall predictions of soil loss by wind from agricultural fields.

#### **More accurate assessment of soil loss from agricultural fields**

This is done by providing more accurate assessments of soil loss from agricultural fields through process-based modeling. WEPS also meets many other needs that were previously not possible through the use of WEQ.

#### **Aid in designing more efficient and Cost-effective erosion control systems**

The simulation model makes it possible to design more efficient and cost-effective erosion control systems...and accurately predict the effects of these control systems as related to soil erosion.

#### **Quantitative information to assist in improved management practices**

Quantitative information, in addition to average annual soil loss, is provided through the detailed reports available that are important in the development of effective management practices.

#### **Estimate suspension soil losses Determine offsite impacts Estimate PM-10 emissions**

WEPS will also provide additional prediction capabilities, not currently available, to determine estimates of suspension soil losses, determining offsite impacts, and providing estimates of emissions of particle matter less than ten microns in size, known as PM-10.

## **Purpose and Goals of WEPS**

### **Purpose and Goals**

- Planning soil conservation systems
- Environmental planning and assessment evaluations
- Offsite impacts of wind erosion estimates

The goal for WEPS is to be the wind erosion tool of choice for designing sound management systems to conserve our soil, air, and water resources. Specific purposes include: the planning of soil conservation systems, providing environmental planning and assessment evaluations, and estimating offsite impacts of wind erosion.

## **What Does WEPS Do?**

**WEPS is based on erosion simulation models to accurately predict:**

- Detachment
- Transport
- Deposition

WEPS simulates the erosion of a soil surface by wind as the fundamental process of soil detachment, which includes clod and crust abrasion, emission, and surface rearrangement. WEPS simulates the process of transport where particles of saltation and creep size are moved as well as suspension, which includes PM10. WEPS also simulates the process of deposition that occurs when particles are trapped in depressions or residue and as the surface is rearranged by wind erosion.

## **What Does WEPS Simulate?**

- Daily Weather
- Water Balance
- Crop Growth
- Residue Decomposition

WEPS simulates weather on a daily basis that drives processes or causes changes in water balance or hydrology, crop growth, and residue decomposition.

### **Daily Changes in Temporal Field Conditions**

- Soil aggregation
- Surface wetness
- Surface roughness
- Residue status (standing/flat)

WEPS simulates changes in temporal field conditions on a daily basis in terms of the soil aggregation size and strength, surface wetness, surface roughness, and how much residue is standing or flat.

### **Common Cultural Practices (management/land use)**

- Tillage
- Planting
- Irrigation
- Harvesting
- Burning

WEPS simulates the effects of common cultural practices typical for field management and land use. These factors include tillage, planting, irrigation, harvesting, and burning.

### **2 Dimensional Spatial Regions**

- Wind barriers
- Fields
- Uniform soil areas
- Common land use/management practices

WEPS simulates the two dimensional space of wind barriers and fields or regions which are represented as having a single soil type an common land use or management.

## **The WEPS Difference from WEQ**

### **How WEPS determines soil loss compared to WEQ**

WEQ makes an erosion calculation along a single, transect that represents the unsheltered

distance across the field. WEPS makes calculations for many grid areas covering the entire field.

The wind speed and direction in WEQ is considered constant throughout the period being evaluated. Wind direction in WEPS varies on a daily basis and wind speed varies by the hour within the day.

Barriers in WEQ only modify the unsheltered field length. In WEPS the barrier type, height, and porosity modify the wind velocity as it travels across the field.

WEQ considers the crop and soil characteristics to remain constant throughout the period of evaluation. With WEPS, soil and crop characteristics change on a daily basis in response to climate and erosion conditions.

These differences will produce more accurate soil loss estimates as the processes simulated closely reflect the actual conditions on a daily time-step process throughout the period of evaluation.

### **How Is WEPS Implemented?**

#### **How is WEPS Implemented?**

WEPS is implemented as a science model within a graphical user interface. The user interface allows for the creation of input run files, or "Projects", the saving of these projects, and the recall of previously saved projects. The projects created are based on the user input and the information contained in the climate, soils, management, and crop/decomposition databases.

The interface executes the science code consisting of the Main controlling program and seven submodels; Hydrology, Management, Soil, Crop, Decomposition, Erosion, and Weather. These submodels are modular in design so that they may be easily modified or replaced as better science is adopted.

The interface also allows for the selection, viewing, and printing of project output and reports.

Lets take a look at the purpose of each of the seven submodels in WEPS.

### **WEPS Submodels**

**The Weather Submodel**

Drives the fundamental physical processes simulated by the other six submodels.

The WEPS weather submodel drives the fundamental physical processes simulated by the other submodels. To do this, the weather submodel simulates precipitation amount, maximum and minimum air temperature, solar radiation, dew point temperature, wind direction on a daily basis, and wind speed on an hourly basis.

**The Hydrology Submodel**

Models the soil water balance in response to weather and field conditions.

The purpose of the WEPS Hydrology submodel is to model soil water balance due to weather conditions and vegetation. This submodel simulates infiltration, percolation, storage, runoff, and deep drainage as well as daily evaporation and transpiration. Hourly surface wetness is used to simulate surface susceptibility to erosion.

**The Soil Submodel**

Models daily changes in soil surface and layer conditions in response to weather processes.

The Soil submodel is used to model daily changes in soil surface and layer conditions in response to the weather processes of wetting and drying, freezing and thawing, and freeze drying. The surface conditions considered include; roughness, crusting, aggregation stability and size, and bulk density.

**The Crop Submodel**

Models daily crop growth in response to weather factors and water stress.

The purpose of the Crop submodel is to model daily crop growth in response to weather factors and water stress. This submodel accounts for biomass production and partitioning, leaf and stem area growth, and plant height.

**The Decomposition Submodel**

Models daily decomposition of residues in response to weather.

The Decomposition submodel purpose is to model daily decomposition of standing, flat and buried residues in response to moisture conditions and temperature. The fall rate of standing residue is also modeled.

### **The Management Submodel**

Models cultural practices which affect a site's susceptibility to wind erosion.

The WEPS Management submodel responds to cultural practices that affect a site's susceptibility to wind erosion. These responses include the effects of the manipulation of soil and biomass properties, which result from management operations.

### **The Erosion Submodel**

Models erosion process when wind speeds exceed threshold for the surface conditions.

Finally, the purpose of the WEPS Erosion submodel is to model erosion processes when wind speeds exceed threshold for the surface conditions. It accounts for trapping and emission of eroding particles, clod and crust abrasion, and surface rearrangement in response to wind driven particle movement. The erosion submodel also simulates creep/saltation and suspension. The PM10 component of suspension is also estimated.

## **WEPS Interface**

### **Field**

- Size
- Shape
- Orientation

The graphical user interface makes WEPS simple to use for field simulations. Users can easily create the field size, shape and orientation.

### **Barriers**

- Locate
- Select
- Modify



It also allows barriers to be located on the field borders and their characteristics easily selected from a drop-down menu. More specific modifications to selected characteristics may be easily made.

**Climate**

- Location

**Soil**

- Select, modify

**Management**

- Select, modify, build

The interface provides a simple method for the user to generate climate information by location selection. Finally, the user may select a soil and modify its properties, as well as select, modify, or build a management scenario.

**Reports**

The output and report options available in WEPS provide reliable and accurate information for evaluation. Information and estimates may be viewed either in summary or detail on; annual soil loss, period soil loss, saltation/creep, suspension, PM10, surface conditions, wind energy, and boundary loss.

**The Benefits****The Benefits of WEPS**

- Accuracy
- Weather driven
- Simulation on a daily time-step
- Estimates loss over entire field
- Reflects effects of cultural practices
- Computed erosion in 2-D space
- Multiple output options

In summary, WEPS is a process-based model that is weather driven with a daily time-step simulation. It estimates soil loss over the entire field and takes into account the effects of cultural practices, computes erosion in a 2-dimensional space, and has multiple output options for the evaluation of information.



**Tutorials: Module 2**

**A Simple Simulation**



### Submodel Report Flags and Command Line Options

#### Submodel Report Flags

To generate various kinds of reports, a flag must be set. To set the option through the interface use the output tab of the Configuration screen. A flag number is entered in the box in the appropriate submodel. A flag of zero, '0', will result in no output generated to the listed file. It should be noted that generating these files may create large file sizes and significantly slow the execution of the WEPS model.

<u>Submodel &amp; flag no.</u>	<u>file name(s)</u>	<u>description</u>
Hydrology		
1	hydro.out	daily output
2	water.out	hourly output for each day
3	hydro.out & water.out	generates both files
4	temp.out	daily soil temperature output by layer
5	temp.out & hydro.out	generates both files
6	temp.out & water.out	generates both files
7	temp.out & water.out & hydro.out	generates all three files
Soil		
1	soil.out	daily submodel output
Management		
1	manage.out	daily submodel output
Crop		
1	crop.out	daily submodel output
Decomposition		
1	dabove.out	daily above ground submodel output
2	dbelow.out	daily below ground submodel output
3	dabove.out & dbelow.out	generates both files
Erosion		
1	erosion.out	currently generates an empty file

**Command Line Options**Windgen 4

usage: wind\_gen4 -D -V -v -h -l -f dbfile -o outfile -s # -x # -r # -b # -y # -u # -d # -?

-D	debug flag
-V	display version and exit
-v	set the verbose option
-h	do not display output title heading
-l	display long (additional) output
-f dbfile	specify wind database file (wind_gen.wdb)
-o outfile	specify output file (stdout)
-s #	specify station WBAN no.
-x #	specify station database index no.
-r #	specify random number seed (54321)
-b #	specify beginning simulation (calendar) year (1)
-y #	specify number of years to simulate (1)
-u #	specify storm duration length in hours (6)
-d #	specify number of days to build storms from (5)

Wind station WBAN code number required Note that only the "-f" option with the location of the appropriate wind\_gen database file to access is required for WEPS 1.0. All other options are either automatically added internally by WEPS 1.0 or are optional. Those that WEPS 1.0 automatically sets are:

-s #  
-y #  
-o outfile

Those that can be added to the command line and should work within WEPS 1.0 are (NOTE that I haven't verified them):

-D  
-v  
-x #  
-r #  
-b #  
-u #  
-d #

Those that can't be specified when wind\_gen4 is run within WEPS 1.0 are:

-V  
-l  
-h

-?

Cligen Version 5.110

CLIGEN V-5.110 - Climate Generator w/ QC-SNDG

Usage: cligen

-S<state number>  
-s<station ID number>  
-i<input file name>  
-o<output file name>  
-b<beginning year>  
-y<duration in years>  
-f old WEPS record format  
-F overwrite output file if it exists  
-H omit header output  
-r<random seed>  
-t<Sim Type (WEPP: 4=SglStm, 5=Contin)>  
-I0 no interpolation (default)  
-I1 linear interpolation  
-I2 Fourier interpolation  
-I3 interpolation to preserve avgs  
-v  
-V verbose  
-h, -?, -\\? help

Make sure there are no spaces between each flag and its parameter. If command line options are omitted, CLIGEN will interactively request the required information.

Note that the "-i" option with the location of the appropriate cligen database file to access, the "-b" option specifying the start year (usually 1), "-t" option with value "5", and the "-F" option are required for WEPS 1.0. All other options are either automatically added internally by WEPS 1.0, are optional, or not applicable when used with WEPS 1.0.

Those that WEPS 1.0 automatically sets are:

-S#  
-s#  
-y#  
-ooutfile

Those that can be added to the command line and should work within WEPS 1.0 are (NOTE

that I haven't verified them):

-r#  
-I0  
-I1  
-I2  
-I3  
-V

Those that can't be specified when cligen5110 is run within WEPS 1.0 are:

-v  
-h  
-?  
-t# (with options values other than 5)

### WEPS 1.0

Usage:

Valid command line options:

- ? Display this help screen
- h Display this help screen
- I Specify if initialization is done and if so, the # loops
  - 0 = No initialization
  - 1 = Runs one management cycle (default)
  - 2 = Runs x management cycles
- S Vary type of value input for 1/3 bar, 15 bar water
  - 0 = 1/3bar(vol) 15bar(vol)
  - 1 = 1/3bar(vol) 15bar(grav)
  - 2 = 1/3bar(grav) 15bar(grav)
  - 3 = use texture based calc (default)

Override 1/3bar, 15bar, bulk density w/ texture estimate
- s Specify soil ifc file input format type
  - 0 = new format (additional parms)
  - 1 = old format
- P Specify path for project run directory
 

Must be specified if other command line switches are used.  
Specifying only the path without the "-P" option works only when no other command line switches used.

E.g: weps path\_to\_weps.run
- R Erosion summary report debug screen dump
  - 0 = no report debugs to screen



- 1 = dump report debugs to screen
- 2 = dump more report debugs to screen
- E Generate stand alone erosion input file on simulation day  
Specify -E2932 to output file on simulation day 2932
- e Generate stand alone erosion input file on DD/MM/YY  
Specify -e020901 to output file on day 2 month 9 year 1  
Day and month must be 2 digits, Year can be 1 to 4 digits

Default options are set to:

-I1 -S3 -s1 -P./ -R0 -Ee(no file)

42:wagner@chepil:~/work/weps/weps.src>

Note that only the "-P" option is required for WEPS 1.0. (It must be the last option specified if more than one option is listed because WEPS 1.0 appends the current WEPS Project Run directory path prior to executing the WEPS science model.

The options that the WEPS 1.0 interface set automatically are:

-Ppath

WEPS 1.0 assumes that the user has specified the "-P" (as the last option) within the WEPS 1.0 configuration panel without the "path". WEPS 1.0 appends the path of the current WEPS Project Run directory prior to executing the WEPS science model.

Those that can be added to the commandline and should work within WEPS 1.0 are (NOTE that I haven't verified them):

-I#  
-S#  
-s#  
-R#  
-E#  
-e#

Those that can't be specified when weps is run within WEPS 1.0 are:

-h  
-?



## Databases

### Weather Database

#### Introduction

The Wind Erosion Prediction System (WEPS) requires wind speed and direction in order to simulate the process of soil erosion by wind. These and other weather variables are also needed to drive temporal changes in hydrology, soil erodibility, crop growth, and residue decomposition in WEPS. The weather generator of WEPS consists of the programs WINDGEN and CLIGEN as well as a user interface and it is capable of simulating the needed weather variables on a daily basis and wind speed on a subdaily basis.

WINDGEN is the program that simulates wind speed and direction for WEPS (Skidmore and Tatarko, 1990; Wagner et al., 1992). It was developed specifically for use with WEPS and stochastically simulates wind direction and maximum and minimum wind speed on a daily basis. In addition, WINDGEN provides the hour at which the maximum wind speed occurs for each day based on historical records. Subdaily wind speeds are generated from within WEPS by the subroutine 'calcwu'.

CLIGEN is the weather generator developed for the Water Erosion Prediction Project (WEPP) family of erosion models (Nicks et al., 1987). It is used with WEPS to generate an average annual air temperature as well as daily precipitation, maximum and minimum temperature, solar radiation, and dew point temperature. Average daily air temperature and elevation for the site are used to calculate average daily air density within WEPS. CLIGEN will not be described in this document. However, those interested in CLIGEN and how it simulates these variables should consult the WEPP documentation (Nicks and Lane, 1989). Both CLIGEN and WINDGEN may be executed separately from the command line, or they may be executed together under a menu driven program called 'CLI\_WIND'. This is a stand-alone program that allows the generation of weather output from CLIGEN and WINDGEN through a user-friendly menu-driven interface.

#### Windgen Development

Prediction of wind speed and direction, like most meteorological variables, is extremely difficult. Even with advanced technology, such as sophisticated numerical models and super computers, using climatological means is only as accurate as predicting meteorological variables a few days in advance (Tribbia and Anthes, 1987). Therefore, we resort to historical statistical information about most meteorological variables and use stochastic techniques to determine likelihood of various levels of those variables.

Various models have been used to describe wind speed distribution. A glance at a frequency versus wind speed histogram shows that the distribution is not best described by the familiar

normal distribution. Distributions that have been used to describe wind speed include the one -parameter Rayleigh (Hennessey, 1977; Corotis et al., 1978), the two parameter gamma (Nicks and Lane, 1989), and the two-parameter Weibull (Takle and Brown, 1978; Corotis et al., 1978). The Weibull is undoubtedly the most widely used model of common wind behavior representing wind speed distributions.

We developed a stochastic wind simulator to furnish wind direction and wind speed as needed by the Wind Erosion Prediction System described by Hagen (1991).

### Compact Database

One important requirement of a wind simulator for wind erosion modeling is to develop a compact database. Although described elsewhere (Skidmore and Tatarko, 1990, 1991), we give here some of the details of creating the compact database. Our database was created from historical monthly summaries of wind speed and wind direction contained in the extensive Wind Energy Resource Information System (WERIS) database at the National Climatic Data Center, Asheville, North Carolina (NCC TD 9793). The WERIS database is described further in Appendix C of Elliot et al. (1986). Data were extracted from WERIS tables and, in some cases, analyzed further to create a database suitable for our needs.

We used data from WERIS, joint wind speed/direction frequency by month (e.g., Table 7.2), to calculate scale and shape parameters of the Weibull distribution function for each of the 16 cardinal wind directions by month.

The cumulative Weibull distribution function  $F(u)$  and the probability density function  $f(u)$  are defined by:

$$F(u) = 1 - \exp[-(u/c)^k] \quad (7.1)$$

and

$$f(u) = dF(u)/du = (k/c)(u/c)^{k-1} \exp[-(u/c)^k] \quad (7.2)$$

where  $u$  is wind speed,  $c$  is scale parameter (units of velocity), and  $k$  is shape parameter (dimensionless) (Apt, 1976). Because anemometer heights varied from location to location, all wind speeds (e.g., Column 1, Table 7.2) were adjusted to a 10 m reference height according to the following:

$$u_2 = u_1(z_2/z_1)^{1/7} \quad (7.3)$$

where  $u_1$  and  $u_2$  are wind speeds at heights  $z_1$  and  $z_2$ , respectively (Elliot, 1979).

**Table 7.2.** Monthly joint wind speed/direction frequency values.

Wind Speed (m/s)	Wind Direction																	Calm	Total
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW			
Calm	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.7	1.7	
1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
2	.3	.1	.1	.0	.1	.1	.2	.1	.3	.1	.5	.5	.6	.4	.5	.2	.0	4.1	
3	.7	.3	.5	.4	.9	.4	.6	.5	.9	.4	1.1	1.1	1.5	.8	.7	.3	.0	11.1	
4	1.0	.6	.8	.4	1.1	.9	1.0	.8	1.9	.6	.8	1.2	1.6	1.2	.7	.5	.0	15.1	
5	.9	.6	.8	.5	.9	.9	1.0	1.3	2.1	.9	1.2	1.2	1.6	.5	.4	.5	.0	15.4	
6	.7	.7	.6	.4	.6	.5	.9	.6	1.6	1.0	1.1	1.2	.7	.6	.3	.5	.0	12.2	
7	1.0	.6	.6	.4	.2	.5	.4	.5	1.6	1.0	1.4	.8	.7	.5	.3	.2	.0	10.0	
8	1.0	.6	.8	.2	.5	.3	.6	.3	1.4	1.2	1.0	.6	.7	.4	.4	.2	.0	10.1	
9	.8	.4	.6	.2	.3	.1	.2	.4	1.0	.8	.7	.6	.6	.4	.2	.3	.0	7.6	
10	.3	.4	.2	.2	.1	.0	.1	.2	.8	.4	.2	.3	.4	.3	.1	.1	.0	4.3	
11	.3	.4	.1	.1	.0	.0	.1	.1	.5	.2	.3	.3	.5	.1	.1	.1	.0	3.1	
12	.2	.1	.0	.0	.0	.0	.0	.1	.0	.1	.1	.2	.4	.1	.1	.0	.0	1.6	
13	.2	.1	.0	.0	.0	.0	.0	.0	.0	.8	.2	.1	.3	.2	.1	.1	.0	1.3	
14	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.2	.1	.1	.0	.0	.7	
15	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.0	.0	.5	
16	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.0	.2	
17	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.1	
18	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	
19	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	
20	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
21-25	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
26-30	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
31-35	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
36-40	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
41-up	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
Total	7.8	4.8	5.1	2.9	4.9	3.8	5.1	4.9	12.2	6.8	8.9	8.5	9.9	5.7	4.0	3.0	1.7	100.0	
Avg	6.9	7.0	6.1	6.0	5.1	5.2	5.5	5.9	6.2	6.7	6.4	6.2	6.4	6.2	5.6	6.3	.0	6.1	

Table 12c of WERIS for March, Lubbock, TX

The calm periods were eliminated, and the frequency of wind in each speed group was normalized to give a total of 1.0 for each of the 16 cardinal directions (e.g., 1 = North, 2 = NNE, 3 = NE, . . . 16 = NNW). Thus,

$$F_1(u) = [(F(u) - F_0)/(1 - F_0)] = 1 - \exp[-(u/c)^k] \quad (7.4)$$

where  $F_1(u)$  is the cumulative distribution with the calm periods eliminated, and  $F_0$  is the frequency of the calm periods. The scale and shape parameters were calculated by the method of least squares applied to the cumulative distribution function (Eqn. [7.6]). Equation [7.6] was rewritten as:

$$1 - F_1(u) = \exp[-(u/c)^k] \quad (7.5)$$

Then by taking the logarithm twice, this becomes:

$$\ln[-\ln(1-F_1(u))] = -k \ln c + k \ln u \quad (7.6)$$

If we let  $y = \ln[-\ln(1 - F_1(u))]$ ,  $a = -k \ln c$ ,  $b = k$ , and  $x = \ln u$ , Equation [7.8] may be rewritten as:

$$y = a + bx \quad (7.7)$$

$F_1(u)$  was calculated from information in tables like Table 7.27 for each wind speed group to determine  $y$  and  $x$  in Equation [7.9]. This gave the information needed to use a standard method of least squares to determine the Weibull scale and shape parameters. To recover the real distribution, we can rewrite Equation [7.6] as:

$$F_1(u) = F_0 + (1-F_0)(1-\exp[-(u/c)^k]) \quad (7.8)$$

Wind direction distribution for each location was summarized by month from the "TOTAL" row near the bottom of Table 7.27 for each location.

Other pertinent data, obtained from the Wind Energy Resource Atlas of the United States (Elliot et al., 1986), included latitude, longitude, city, state, location name, Weather Bureau Army Navy (WBAN) number, agency responsible for the weather station, period of record, anemometer height and location, and number of observations per 24-hour period.

We eliminated WERIS sites from our database if they represented less than 5 years of data, the anemometer height was not known, or fewer than 8 observations were taken per day. Where more than one satisfactory observation period/site remained in a metropolis, we picked the site with the best combination of the following: (1) maximum number of hours per day observations were taken, (2) longest period of record, (3) 1 hourly versus 3 hourly observations, and (4) best location of anemometer (ground mast > beacon tower > roof top > unknown location). The WINDGEN database currently consists of statistical parameters for 672 locations in the United States.

From WERIS, we obtained a ratio of maximum/minimum mean hourly wind speed and hour of maximum wind speed by month (e.g., Table 7.3). Tables 7.3, 7.4, 7.5, and 7.6 give examples of wind information we compiled into a compact database.

**Table 7.3.** Ratio of maximum to minimum hourly wind speed (max/min) and hour of maximum wind speed.

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
max/min	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.5	1.6	1.6	1.5
hour max	15	12	15	15	18	18	18	15	15	15	12	15

Values from WERIS Table 5 for Lubbock, TX (Skidmore and Tatarko, 1991) where Month 1 = January.

**Table 7.4.** Wind direction distribution by month in percent.

Wind Direction	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	8.2	9.7	7.8	5.5	5.3	3.1	2.3	2.9	5.9	6.3	8.8	9.0
2	5.0	4.9	4.8	3.6	3.7	2.2	1.5	2.6	4.8	5.0	4.4	4.8
3	5.0	5.9	5.1	4.1	4.1	3.2	3.9	4.2	6.3	5.3	4.8	4.7
4	3.8	4.2	2.9	4.5	4.8	4.1	3.8	4.7	4.9	4.1	3.1	3.1
5	4.0	4.3	4.9	5.3	5.9	5.0	5.9	6.7	6.3	4.3	4.4	2.2
6	3.1	3.8	3.8	4.7	6.6	6.1	5.7	6.3	5.7	3.0	3.2	1.9
7	3.3	3.8	5.1	6.5	10.5	10.4	10.0	9.7	7.5	4.2	3.4	2.1
8	2.9	3.3	4.9	4.9	8.3	9.5	11.6	14.9	13.6	9.0	5.4	3.7
9	9.8	8.7	12.2	16.4	16.4	26.8	27.4	24.1	18.6	19.7	11.7	9.4
10	6.0	5.7	6.8	6.5	6.9	9.2	8.8	7.2	7.9	9.6	7.5	7.4
11	9.6	8.5	8.9	7.7	7.3	5.9	5.9	5.1	6.2	8.2	9.9	10.1
12	9.6	9.3	8.5	7.9	4.7	3.4	2.4	2.8	3.5	6.0	9.0	9.8
13	12.3	10.8	9.9	6.7	5.1	3.3	2.0	1.7	3.5	6.1	9.0	11.8
14	6.3	6.2	5.7	4.6	3.0	1.5	1.0	1.1	1.7	3.2	5.1	7.7
15	4.7	4.9	4.0	3.4	2.6	1.6	0.8	1.1	2.0	3.0	4.3	5.3
16	3.8	3.4	3.0	3.0	1.8	1.1	0.6	1.1	2.1	2.9	3.0	4.0
17	2.7	2.7	1.7	1.4	1.8	1.5	3.1	5.0	4.0	3.6	4.8	4.3

Directions are clockwise with 1 = north and Month 1 = January. Direction 17 represents calm periods. Values for Lubbock, TX (Skidmore and Tatarko, 1991).

**Table 7.5.** Weibull shape parameters by month and direction.

Wind Direction	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	2.5	2.5	2.7	2.6	2.8	2.3	2.2	2.6	2.3	2.5	2.7	2.7
2	2.8	2.4	3.2	2.9	2.8	2.7	3.2	2.3	3.1	2.8	2.7	2.6
3	2.8	3.1	3.3	2.8	2.7	2.9	2.8	3.3	3.2	3.3	3.0	3.2
4	3.9	3.4	3.0	3.5	3.0	2.6	2.8	2.9	3.2	3.1	2.7	3.2
5	3.1	3.2	3.3	2.9	3.0	3.4	3.1	3.2	3.3	3.0	3.6	2.8
6	3.4	3.6	3.9	3.3	3.6	4.4	3.7	3.9	3.3	3.5	3.6	5.1
7	3.7	3.3	3.3	3.3	3.4	3.6	3.5	3.5	3.9	4.1	3.6	5.4
8	3.2	4.1	3.3	3.5	3.3	3.5	3.8	3.7	3.5	2.9	3.0	4.5
9	2.9	3.2	3.6	3.3	3.3	3.7	3.7	3.7	3.4	3.3	3.3	3.2
10	3.1	3.5	3.7	3.7	3.2	3.5	3.9	3.6	4.0	3.2	3.5	3.2
11	3.4	3.2	2.7	3.2	3.2	3.0	3.5	3.0	3.4	3.0	3.2	3.2
12	2.5	2.6	2.5	2.4	2.5	2.9	3.4	3.6	3.0	2.7	2.6	2.6
13	2.1	2.4	2.2	2.5	2.6	2.2	3.3	3.1	3.0	2.4	2.2	2.2
14	2.1	2.2	2.3	2.5	2.4	3.6	4.1	3.5	2.6	2.4	1.8	2.0
15	2.4	2.6	2.2	2.5	2.5	3.1	3.3	2.9	2.9	2.0	2.2	2.3
16	2.2	2.6	2.7	2.3	2.8	3.3	2.6	3.5	2.5	2.1	2.4	2.4
17	2.6	2.6	2.7	2.9	3.0	3.1	3.3	3.2	3.0	2.7	2.6	2.6

The directions are clockwise starting with 1=north. Direction 17 is for total wind. Values are for Lubbock, TX (Skidmore and Tatarko, 1991).

**Table 7.6.** Weibull scale parameters by month and direction in m/s.

Wind Direction	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	8.0	8.2	8.8	8.3	8.0	7.6	5.8	5.0	6.4	7.5	7.5	7.9
2	8.2	9.2	9.0	8.6	8.3	7.6	6.0	5.7	7.3	7.5	6.7	8.1
3	6.6	7.8	8.0	8.3	7.9	7.2	5.8	5.8	5.9	7.0	6.5	6.8
4	6.5	6.5	7.8	6.9	7.3	6.3	5.9	5.2	5.3	6.2	5.7	6.3
5	6.0	6.3	6.7	6.4	6.6	6.3	5.2	4.8	4.6	5.2	5.0	5.0
6	5.3	6.4	6.8	7.1	7.1	6.2	5.3	5.0	5.2	5.1	5.1	4.2
7	5.5	6.4	7.2	7.2	7.4	6.8	6.0	5.5	5.5	5.3	4.8	5.2
8	5.9	6.1	7.5	8.5	8.0	7.5	6.3	5.8	5.9	6.2	5.8	5.2
9	6.2	7.0	7.9	8.5	8.1	8.0	6.8	6.5	6.5	6.6	6.2	6.5
10	7.2	7.2	8.7	8.5	8.1	7.7	6.9	6.5	6.9	6.9	6.9	7.4
11	7.3	7.6	8.2	8.4	7.6	6.9	6.1	5.9	6.1	6.2	6.5	6.9
12	6.5	7.0	8.0	8.6	7.8	7.0	5.4	5.0	5.2	5.9	6.4	6.0
13	6.7	6.8	8.3	8.8	7.2	6.4	4.9	4.4	5.3	5.1	6.3	6.4
14	7.1	7.2	7.8	8.1	7.0	5.6	4.3	4.2	4.6	5.1	6.0	6.9
15	6.1	6.1	7.2	7.2	7.1	5.3	4.6	4.5	4.4	4.9	6.4	6.5
16	7.1	7.7	7.7	8.3	6.6	5.7	4.8	3.9	4.9	6.4	7.1	7.2
17	6.8	7.3	8.1	8.2	7.7	7.3	6.3	5.8	5.9	6.3	6.4	6.7

Directions are clockwise starting with 1=north. Direction 17 is for total wind. Values for Lubbock, TX. Wind speed adjusted to height of 10 meters (Skidmore and Tatarko, 1991).

Following is an example WINDGEN database record for Goodland, Kansas.



Example WINDGEN database entry for Goodland, Kansas.

```

1      # 23065 USA KS GOODLAND
2      39 22 N 101 42 W 1112 19500609 19640322 ARW
3      2.4 2.8 2.6 2.2 2.5 2.4 3.7 3.5 3.3 2.9 3.1 3.1
4      7.7 8.2 10.1 9.4 6.8 5.6 4.7 4.5 6.3 7.2 7.0 6.2
5      4.6 4.0 5.7 5.6 5.8 5.1 4.9 4.6 6.2 4.9 3.8 2.8
6      2.3 2.9 3.5 4.0 5.8 5.9 5.1 4.5 3.8 3.7 2.2 1.7
7      1.3 1.6 2.5 3.2 4.4 4.3 3.4 3.4 3.6 1.6 1.1 1.1
8      1.1 1.1 1.9 2.6 3.2 3.4 3.5 2.8 2.9 1.5 1.0 0.8
9      1.8 2.4 3.7 5.2 6.2 5.9 6.7 5.1 4.4 3.3 1.8 1.5
10     2.5 3.9 6.0 6.3 8.2 9.0 11.2 9.7 6.0 5.4 3.3 2.6
11     5.8 7.2 8.2 10.5 12.9 14.0 16.8 17.2 14.0 11.2 5.1 4.6
12     6.0 6.9 7.2 9.4 11.0 13.4 13.6 13.4 14.8 10.4 7.2 5.2
13     4.7 4.5 4.7 6.2 5.7 8.3 7.6 8.3 8.2 6.3 6.0 4.4
14     8.2 7.2 5.5 5.0 4.3 5.0 5.3 6.2 5.9 6.9 8.3 8.7
15     16.3 11.8 7.9 5.9 5.6 4.0 3.4 4.0 5.0 8.9 13.8 15.4
16     6.6 5.5 3.6 2.5 1.9 1.5 1.4 2.2 2.4 4.0 5.5 7.3
17     8.7 7.7 5.7 4.2 3.8 2.8 2.3 2.9 3.0 5.8 9.3 11.2
18     10.6 10.8 8.7 7.7 5.8 4.2 2.9 3.6 4.7 7.2 9.0 12.1
19     9.4 11.5 12.3 10.2 6.2 5.2 3.5 4.1 5.7 8.9 12.4 11.4
20     7.89 8.11 8.61 8.15 7.03 6.53 5.89 5.88 6.50 6.72 7.77 7.16
21     6.99 7.07 7.26 6.83 6.49 6.60 6.21 5.64 6.48 5.78 6.82 6.01
22     5.08 5.36 6.08 5.90 6.26 6.16 5.91 5.44 5.13 5.35 5.23 4.85
23     4.86 4.36 5.89 6.16 6.70 6.32 6.01 5.20 5.80 4.62 4.50 4.39
24     4.40 4.30 5.59 5.56 5.51 5.88 5.21 4.86 5.47 4.50 4.34 4.50
25     4.58 5.26 5.67 6.19 6.64 6.59 5.74 5.58 5.31 4.45 4.21 4.50
26     5.01 5.73 6.85 6.85 7.14 6.65 6.22 6.00 5.47 5.80 5.60 5.82
27     5.99 6.41 7.42 8.13 7.82 7.80 6.80 6.91 7.17 6.94 6.39 6.19
28     6.26 6.63 7.65 8.12 7.76 7.83 6.98 6.83 7.47 7.24 6.72 6.37
29     6.14 6.64 7.31 7.50 7.25 8.03 6.75 6.48 6.94 6.81 6.88 6.77
30     5.62 5.23 6.28 5.95 5.81 5.93 5.37 5.20 5.28 5.25 5.78 5.89
31     5.18 5.18 5.42 5.22 5.22 5.07 4.31 4.28 4.35 4.82 5.02 5.13
32     4.71 4.49 4.89 4.62 4.06 3.55 3.16 3.28 3.97 4.09 4.43 4.70
33     5.27 5.39 6.09 6.00 5.37 5.34 4.19 4.52 4.19 4.72 5.67 5.66
34     6.77 6.93 7.86 7.93 7.27 5.70 4.41 4.56 5.29 6.08 6.70 6.65
35     8.05 8.71 9.67 9.10 7.41 6.81 5.84 5.85 6.85 7.52 8.27 8.51
36     2.32 2.41 2.29 2.70 2.43 2.41 2.37 2.43 2.47 2.69 2.64 2.48
37     2.82 2.51 2.59 2.54 2.83 2.55 2.43 2.67 2.48 2.77 2.47 2.97
38     3.07 2.87 2.56 2.88 2.61 2.57 2.40 2.37 2.82 2.82 2.79 2.69
39     3.60 4.00 3.27 2.36 2.45 2.67 2.84 2.68 3.03 3.50 2.95 2.84
40     4.04 2.58 2.91 3.06 2.56 2.65 2.47 2.76 2.83 3.67 2.65 3.77
41     3.36 3.02 2.86 2.52 2.56 2.56 2.50 2.64 2.75 3.08 3.60 3.67
42     2.53 2.74 2.79 2.60 2.61 2.74 2.70 2.68 2.85 2.86 2.27 2.52
43     3.14 3.02 2.91 2.93 2.97 2.81 3.15 3.06 3.15 2.97 2.99 2.88
44     3.20 2.74 2.71 2.85 2.62 3.01 3.23 3.08 3.14 3.00 2.99 3.27
45     3.48 2.78 2.67 3.02 2.67 3.10 3.16 2.84 3.32 2.80 2.96 2.66
46     3.26 3.23 2.78 2.90 2.69 2.84 2.74 2.99 3.11 3.43 3.06 3.35
47     3.84 3.42 3.36 3.24 3.37 2.62 3.34 2.97 3.67 4.03 4.12 3.94
48     3.36 3.37 2.67 3.16 3.09 3.08 2.96 4.30 2.95 3.17 3.63 3.63
49     3.17 3.18 2.29 2.62 2.67 2.59 2.39 2.64 2.94 2.94 2.96 3.01
50     2.42 2.32 2.20 2.16 2.07 2.32 2.60 2.53 2.12 2.24 2.16 2.35
51     2.45 2.50 2.42 2.39 2.58 2.40 2.25 2.34 2.37 2.56 2.49 2.50
52     1.4 1.4 1.3 1.4 1.4 1.4 1.6 1.6 1.3 1.4 1.4 1.4
53     12 12 11 14 15 15 17 17 15 13 12 13

```

**Meaning of each item in the preceding example:**

line number	Item	Meaning
<i>1</i>	#	Starting mark
	23065	A unique number (WBAN) associated with the WERIS (Wind Energy Resource Information System) database site
	USA	Country
	KS	State
	Goodland	Name of the site
<i>2</i>	39 22 N	Latitude of the location (39° 22' N)
	101 42 W	Longitude of the location (101° 42' W)
	1112	Elevation (m)
	19500609	Beginning record date (yyyymmdd)
	19640322	Ending record date (yyyymmdd)
	ARW	A three letter code containing record information:
	first letter <i>A</i> -- # of observation/day	
	A	24
	B	19-23
	C	12-18
	D	5-11
	E	4
	F	Less than 3
	G	Greater than 24
	U	Unknown
	second letter <i>R</i> -- Anemometer location	
	R	Roof-top
	G	Ground mast
	B	Beacon tower

E	Estimated Wind, no anemometer
O	Other
U	Unknown

*third letter*      *W* -- Recording agency

A	Air Force
D	US Department of Agriculture
E	Experiment Station
N	Navy
W	Weather Service
F	FAA
O	Other
U	Unknown

- 3-18**      2.4 ... Wind direction distribution by month (column) and direction (16 rows).
- 19**      9.4 ... Percent of time calm (no wind) by month.
- 20-35**      7.89 ... Weibull scale parameter by month (column) and direction (16 rows), C (m/s).
- 36-51**      2.32 ... Weibull shape parameter by month (column) and direction (16 rows), K.
- 52**      1.4 ... The average ratio of maximum mean hourly to minimum mean hourly observed wind speeds by month.
- 53**      12 ... Average hour of maximum wind speed by month.

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**Soil Database**

The soil database for WEPS is derived from the National Soil Information System (NASIS) developed and maintained by the USDA-NRCS. Below is a list of the data elements which are obtained from NASIS and a brief description of each.

<b>Header</b>	<b><u>Descriptive Name (units) - definition - data type</u></b>
<b>state</b>	State name - character
<b>county</b>	County name - The name of the County - character
<b>ssaname</b>	Soil survey area name - The name given to the specified geographic area (e.g., soil survey area) - character
<b>ssaid</b>	Soil survey area symbol - A symbol that uniquely identifies a single occurrence of a particular type of area (e.g Lancaster Co., Nebraska is NE109) - character
<b>musym</b>	Map Unit Symbol - The symbol used uniquely identify the soil map unit in the soil survey - character
<b>compname</b>	Soil component name - The correlated name of the map unit - character
<b>compct</b>	Soil component percent (%) - The percentage of the component of the map unit - integer
<b>taxorder</b>	Soil taxonomic order - The soil order of the soil component name - character
<b>slope</b>	Slope gradient (%) - The difference in elevation between two points - float
<b>albedodry</b>	Albedo of the bare dry surface soil - The estimated ratio of the incident shortwave (solar) radiation that is reflected by the air dry, less than 2 mm fraction of the soil (unitless) - float
<b>#of_layers</b>	Number of soil horizons or layers - integer
<b>hzdept</b>	Depth to top of horizon (cm) - The distance from top of the soil to the top of soil horizon - integer

<b>hzdepb</b>	Depth to bottom of horizon (cm) - The distance from top of the soil to the base of soil horizon - integer
<b>hzthk</b>	Thickness of soil horizon (cm) - A measurement from the top to bottom of the soil horizon - integer
<b>texture</b>	Soil texture - An expression, based on the USDA system of particle sizes, for the relative proportions of various size groups - character
<b>%claytotal</b>	Clay (%) - Mineral particles less than 0.002 mm in equivalent diameter as a weight percentage of the total soil - float
<b>%sandtotal</b>	Sand (%) - Mineral particles 0.05 to 2.0 mm in equivalent diameter as a weight percentage of the total soil - float
<b>%sandco</b>	Coarse sand (%) - Mineral particles 0.5 to 1.0 mm in equivalent diameter as a weight percentage of the total soil - float
<b>%sandmed</b>	Medium sand (%) - Mineral particles 0.25 to 0.5 mm in equivalent diameter as a weight percentage of the total soil - float
<b>%sandfine</b>	Fine sand (%) - Mineral particles 0.10 to 0.25 mm in equivalent diameter as a weight percentage of the total soil - float
<b>%sandvf</b>	Very fine sand (%) - Mineral particles 0.05 to 0.10 mm in equivalent diameter as a weight percentage of the total soil - float
<b>dbthirdbar</b>	Bulk density 1/3 bar (Mg/m <sup>3</sup> ) - The oven dried weight of the less than 2.0 mm soil material per unit volume at a tension of 1/3 bar - float
<b>dbovendry</b>	Bulk density oven dry (Mg/m <sup>3</sup> ) - The oven dried weight of the less than 2.0 mm soil material per unit volume - float
<b>wtenthbar</b>	Water 1/10 bar (%) - The amount of soil water retained at a tension pf 1/10 bar (10 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil weight. If the soil is a sand, the 1/10 bar water will be listed, if not, the column is blank. - float
<b>wthirdbar</b>	Water 1/3 bar (%) - The amount of soil water retained at a tension pf 1/3 bar (33 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil

weight - float

- wfifteenbar** Water 15 bar (%) - The amount of soil water retained at a tension pf 15 bar (1500 kPa), expressed as a percentage of the less than 2 mm, oven-dry soil weight - float
- ksat** Saturated hydraulic conductivity ( $\mu\text{m/s}$ ) - The amount of water that would move vertically through a unit area of saturated soil in unit time under unit hydraulic gradient - float
- cec7** Cation exchange capacity (meq/100 g) - The amount of exchangeable cations that a soil can adsorb at pH 7.0 - float. If the soil has a pH < 5.5, the column is blank, otherwise the effective cation exchange capacity will be listed.
- eccec** Effective Cation exchange capacity (meq/100 g) - The sum of  $\text{NH}_4\text{OAc}$  extractable bases plus KCl extractable aluminum used for soils that have pH < 5.5 - float. If the soil has a pH < 5.5, the effective cation exchange capacity will be listed, if not the column is blank.
- om** Organic matter (%) - The amount by weight of decomposed plant and animal residue expressed as a weight percent of the soil material - float
- caco3** Calcium carbonate equivalent (%) - The quantity of Carbonate ( $\text{CO}_3$ ) in the soil expressed as  $\text{CaCO}_3$  as a weight percentage of the < 2 mm soil - integer
- ph1to1h2o** Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the 1:1 soil to water method. - float. If the soil is a mineral soil, the pH will be listed, if not, the column is blank.
- ph01mcac12** Soil Reaction - pH (unitless) - A numerical expression of the relative acidity or alkalinity of a soil using the 0.01M calcium chloride method. - float. If the soil is a Histosol, the pH will be listed, if not, the column is blank.
- fragvol** Rock fragments by volume (%) - The volume of the horizon occupied by 2 mm or larger fraction - integer
- lep** Linear extensibility percent (%) - The linear expression of the volume difference of the natural soil fabric at 1/3 or 1/10 bar water content and oven dryness. The volume change is reported as a percent change for the whole soil. - float

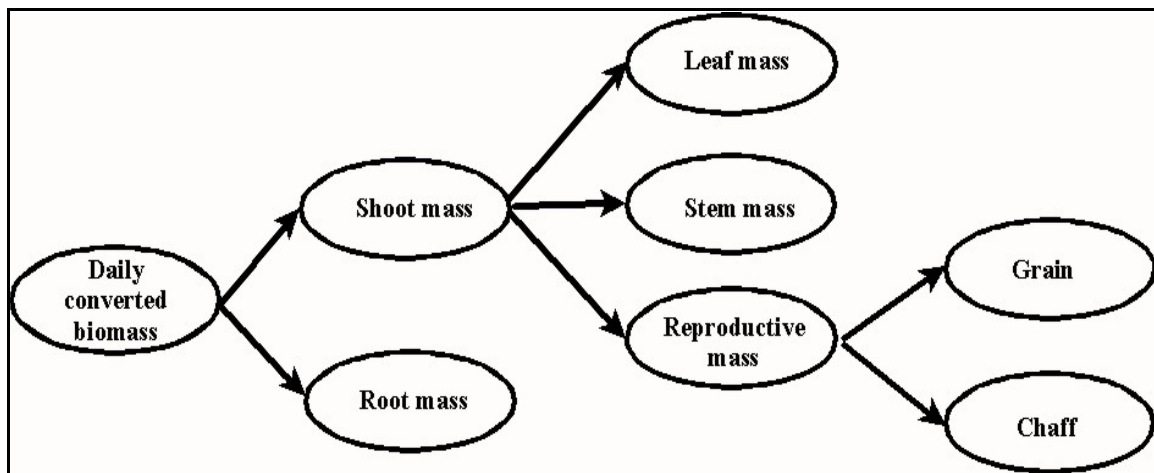
The WEPS soil database format as downloaded from NASIS, is an ascii text file with each element being separated by the pipe (|) symbol. Each layer is on one line, with various soils listed one after another. Note that there are two places for pH and two for CEC. Only one of each of these will be populated depending on the type of soil. So only one value should be taken from the two columns to fill out the corresponding column in the ifc file. The WEPS soil interface then converts the units and generates further data elements as required by WEPS.



## Crop Database




### Introduction

In the WEPS plant growth submodel biomass is converted from solar radiation and partitioned to root and 'shoot' parts (Fig. 7.28). The shoot mass is partitioned into leaf, stem, and reproductive masses. Finally the reproductive mass is partitioned into grain and chaff parts. Development of the crop in WEPS is a function of the heat unit index, which is the ratio of the cumulated growing degree days at any time to the seasonal growing degree days. The crop reaches maturity when the heat unit index is 1. To perform these and other operations the WEPS plant growth model uses crop parameters. A short description of all the database parameters used in the WEPS plant growth model is below. The parameters consist of a mixture of plant growth, decomposition, and other related information used to simulate plant growth and decomposition in the WEPS model.



**Figure 7.28.** Schematic of biomass partitioning in WEPS.

### Crop Parameters

Accessing the crop parameters: Many of the crop database parameters can be accessed (i.e., viewed or modified) through the WEPS crop rotation editor. Double clicking on the folder icon , on the left side of the main screen management box, will bring up the management crop rotation editor. This allows the user to modify management scenarios and save them to other file names. The crop parameter window can be accessed by clicking on the folder icon  next to a listed crop on the left side of the 'Crop' column of the MCREW window. The crop parameters are grouped in 6 tabs. Many of the parameters are assumed to be crop specific, and therefore should not be changed unless the user establishes that a parameter(s) does not work for their condition. At the top of the crop parameter window is the 'Crop Name' selection list. Clicking on the down arrow  brings up a list from which to select

a crop. This is a list of the common name of the crop, which may be followed by additional descriptors when there are multiple entries for the same crop. For example, 'soybeans, MG 0, 95 days' means that the name of the crop is soybeans belonging to maturity group 0, and takes about 95 days to mature.

**Figure 7.29.** Seeding tab window.

Seeding tab (Fig 7.29): This tab has two variables, 'plant population' and 'tillering factor', that are read from the crop database. Plant population is the number of plants or seedlings per unit area. The model assumes 100% germination rate. The tillering factor is the number of tillers per plant. Normally the model is run with the 'Biomass adjustment factor' set to 1.0. However, the model can be run by entering the desired biomass adjustment factor. This choice can be made by clicking on the 'use given biomass and ratio adjustment factors' circle and entering the desired biomass adjustment factor.

It is recommended that the use of a biomass adjustment factor be limited to cases when it can be demonstrated that biomass production was influenced by processes other than those simulated in the model. The default plant population (seeding rate) can be changed to suit the conditions being simulated. As mentioned above plant population density will have an impact on amount of vegetative cover, and therefore erosion rates, during the early part of the growing period. It can also have an impact on 'yield'.

Growth tab (Fig. 7.30): This tab displays ten parameters from the crop database. First the user must select the mode of calculation; whether to use the 'days to maturity' (DTM) mode, or the 'seasonal growing degree days (GDD<sub>s</sub>)'. This is done by clicking the appropriate circle labeled 'Crop matures on average in Days shown' or 'Crop Matures in Heat Units shown'. GDD<sub>s</sub> is the total growing degree days from planting to physiological maturity. In the GDD<sub>s</sub> mode the user can either use the default GDD<sub>s</sub> or supply another value. In the DTM mode the model computes GDD<sub>s</sub> internally. A brief description of DTM follows. For annual crops DTM is the number of days from planting to physiological maturity. For perennial crops (e.g. alfalfa), DTM is the number of days from start of spring growth to physiological maturity of seed. For perennials, the date of spring planting (or start of spring growth) is not a data entry, but calculated internally in the Crop submodel. For root and

**Crop Parameters**

Crop Name: wheat, winter, hard

Seeding Growth Frost Partitioning Size Decomposition

☐ Warm season legume (soybeans, etc.)  
☐ Cool season legume (peas, etc.)  
☐ Perennial Legume (alfalfa, etc.)  
☐ Spring Seeded and Warm Season Annuals (cotton, sunflowers, corn, etc.)  
☒ Cold Season Annuals (winter wheat, winter canola)  
☐ Perennials (pasture, etc.)

Grain (seed) fraction of reproductive biomass component: 0.8 fraction

light extinction coefficient: 0.6

Ratio of heat units (start of senescence/total): 0.8 fraction

maximum crop height: 1.2 m

maximum root depth: 2 m

minimum temperature for plant growth: 32 deg F

optimal temperature for plant growth: 59 deg F

☒ Crop matures on average in Days shown  
☐ Crop Matures in Heat Units shown

time of uninterrupted growth to maturity: 240 days

Growing degree days to maturity: 3240 deg F day

Biomass conversion efficiency: 35 (t/ha)/(MJ/m<sup>2</sup>)

Save Crop to Database OK Cancel

**Figure 7.30.** Growth tab window.

method should be used, most users may be more familiar with the number of days a crop may take to mature than with how many growing-degree-days a crop takes to mature. However, the GDD<sub>s</sub> method should be used for cover crops that are planted out of season. It is recommended that most of the remaining parameters in this tab should not be changed without proper evaluation.

A brief definition of the parameters in this tab is below:

Grain (seed) fraction of reproductive biomass component: Harvestable fraction of reproductive biomass. For grain crops the reproductive mass is the ratio of grain mass to reproductive mass (grain/(grain+chaff)). For corn the 'chaff' will include the husk and the shank. For many field crops a value of 0.8 is used.

light extinction coefficient: A measure of how much of the light energy is transmitted

vegetable crops, DTM is the number of days from the planting/transplanting date to market 'maturity'. Similarly, for tropical fruit crops (e.g. pineapple) DTM is the number of days from planting to market maturity of fruit. For sugarcane, DTM is the number of days from planting to the time when the cane is ready for cutting. For cover crops DTM is the time from planting at the normal planting time to physiological maturity. If a user feels that the default value of DTM is either too long or too short then the user should replace it to more correctly represent the cultivar or variety being simulated. Since DTM is used in internal computations of GDD<sub>s</sub>, it determines the length of the growing season. If the user chose the GDD<sub>s</sub> mode then the user must ensure that the default GDD<sub>s</sub> applies to the variety being simulated. In most cases it is recommended that the DTM

through a canopy. This parameter is a constant in the equation used to convert light energy into biomass. Values may range from 0.3 to 0.6 for crops with upright leaves, and from 0.6 to 1.05 for crops with horizontal leaves.

Ratio of heat units (start of senescence/total): This parameter determines when senescence will start (e.g. a value of 0.8 indicates that senescence will start when 80% of the growing season is completed).

maximum crop height: The height a plant can reach under ideal growing conditions.

maximum root depth: The depth that the root of a plant can reach under ideal growing conditions.

minimum temperature for plant growth: The average daily air temperature below which the model will not allow plant growth (the temperature stress factor is 0.0).

optimal temperature for plant growth: The average daily air temperature at which the model will allow maximum growth (the temperature stress factor is 1.0).

time of uninterrupted growth to maturity: This label is misleading and should be changed to read: days from planting to physiological (or market) maturity. For annual grain crops, the average number of days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the number of days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the number of days from spring growth to maturity of seed.

Growing degree days to maturity: For annual grain crops, the average seasonal growing-degree-days from planting to maturity of seed; for vegetable, fruit and root crops, sugarcane, and tobacco it is the average seasonal growing-degree-days from planting (or ratooning) to harvest; for perennials (e.g. alfalfa) it is the average seasonal growing-degree-days from spring growth to maturity of seed.

Biomass conversion efficiency: Energy to biomass conversion parameter at ambient CO<sub>2</sub> levels. This parameter determines how effective a crop is in converting photosynthetically active radiation into structural biomass. This parameter may be changed based on field experimentation.

**Crop Parameters**

Crop Name: wheat, winter, hard

Seeding Growth **Frost** Partitioning Size Decomposition

Upper frost damage threshold temperature: 23 deg F

Lower frost damage threshold temperature: 5 deg F

Damage at upper frost damage threshold temperature: 0.01 fraction

Damage at lower frost damage threshold temperature: 0.1 fraction

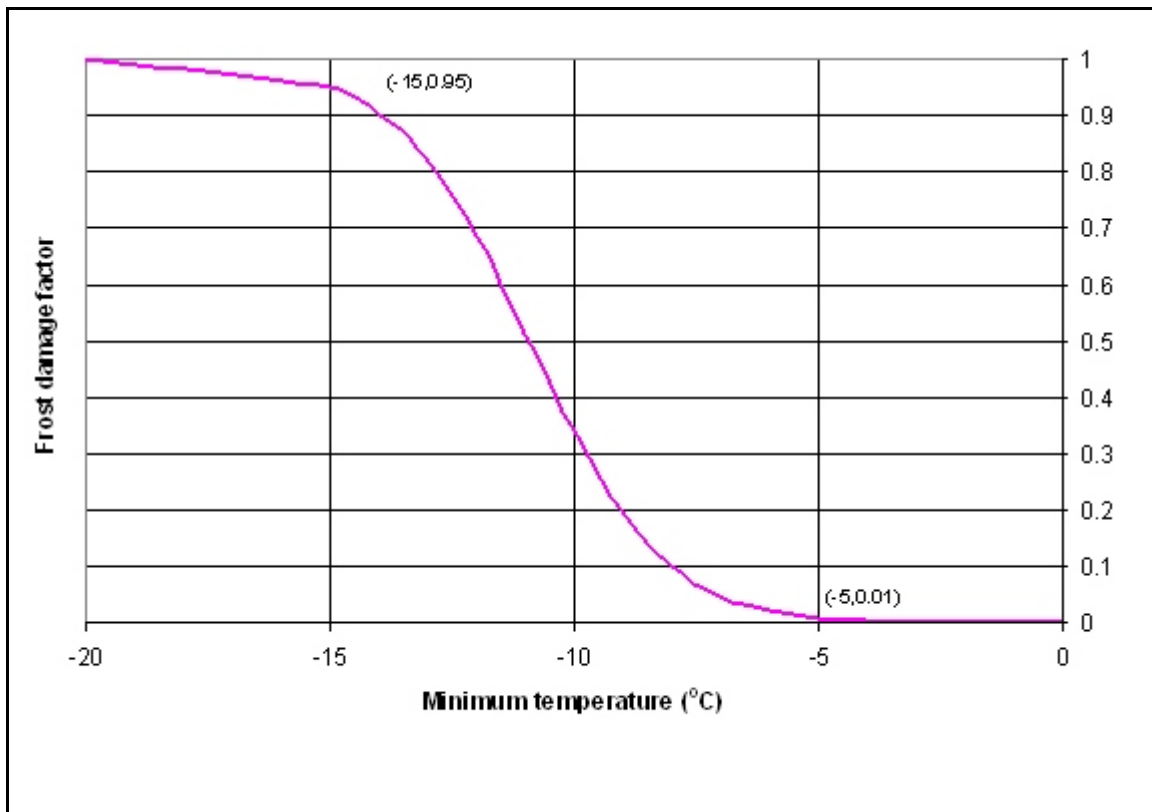
Save Crop to Database OK Cancel

**Figure 7.31.** Frost tab window.

assistance.

**Frost tab (Fig. 7.31):** The Crop submodel reduces green leaf area in response to frost. The frost parameters determine the shape of a sigmoid curve used in assessing rate of green leaf area reduction in response to temperatures below freezing (Fig. 7.32).

**Note:** Changing parameters on the 'Frost' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. Contact WERU for more



**Figure 7.32.** Example frost damage curve.

The frost parameters follow:

Upper frost damage threshold temperature: This label should be changed to read ‘upper frost damage temperature’.

Lower frost damage threshold temperature: This label should be changed to read ‘lower frost damage temperature’.

Damage at upper frost damage threshold temperature: This label should be changed to read ‘relative damage at upper frost temperature’

Damage at lower frost damage threshold temperature: This label should be changed to read ‘relative damage at lower frost temperature’.

Crop Parameters	
Crop Name:	wheat, winter, hard
<div>Seeding Growth Frost <b>Partitioning</b> Size Decomposition</div>	
leaf fraction coefficient a:	0.013
leaf fraction coefficient b:	0.8013
leaf fraction coefficient c:	0.4293
leaf fraction coefficient d:	-0.086
reproductive mass coefficient a:	-0.018
reproductive mass coefficient b:	0.932
reproductive mass coefficient c:	0.556
reproductive mass coefficient d:	0.0736
<div>Save Crop to Database OK Cancel</div>	

**Figure 7.33.** Partitioning tab window.

Partitioning tab (Fig 7.33): There 8 parameters in this tab. These parameters are the coefficients in a 4-parameter logistic function to determine partitioning of ‘shoot’ biomass into leaf or reproductive masses. The first 4 coefficients are for leaf and the last 4 are for reproductive (Fig. 7.34).

**Note:** Changing parameters on the ‘Partitioning’ tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field

data if new values are to be generated and used. Contact WERU for more assistance. The parameters are:

leaf fraction coefficient a: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into leaves.

leaf fraction coefficient b: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into leaves.

leaf fraction coefficient c: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted ‘shoot’ (above ground) biomass that goes into



leaves.

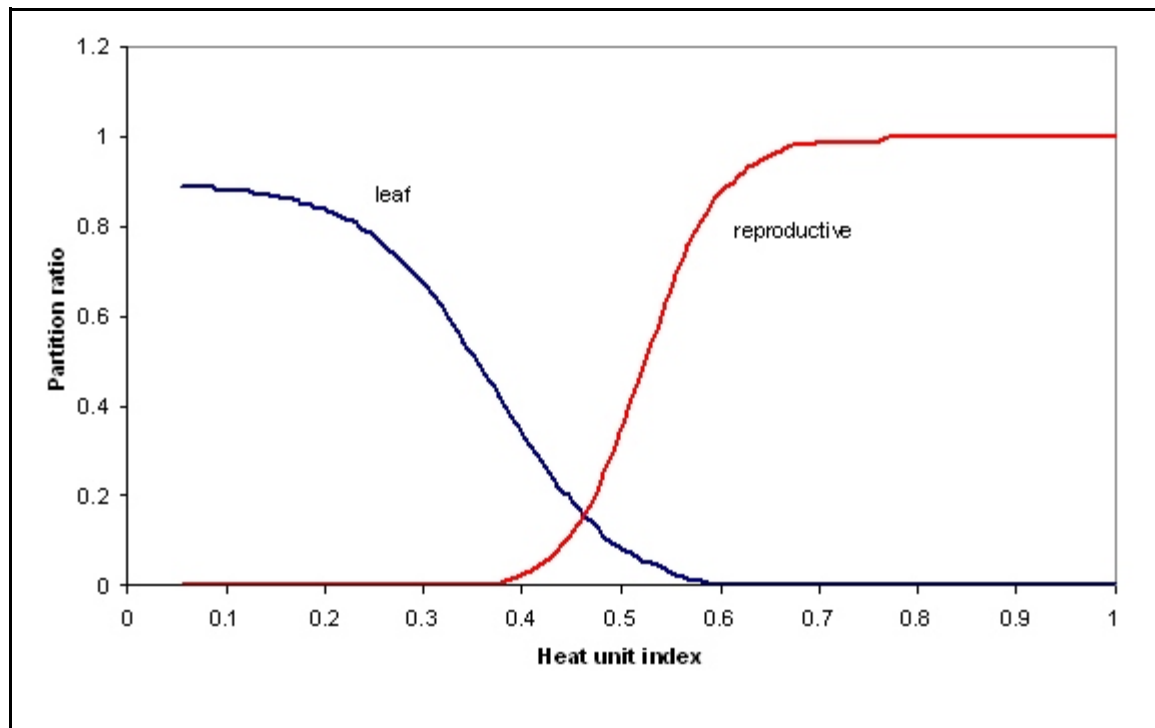
leaf fraction coefficient d: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into leaves.

reproductive mass fraction coefficient a: The intercept of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient b: The asymptote of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient c: The inflection point of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.

reproductive mass fraction coefficient d: The inverse of the slope of a 4-parameter logistic function used in computing the fraction of daily converted 'shoot' (above ground) biomass that goes into reproductive parts or yield.



**Figure 7.34.** Example shoot and reproductive growth curves.

**Crop Parameters**

Crop Name: wheat, winter, hard

Seeding Growth Frost Partitioning **Size** Decomposition

crop height curve shape coefficient a: 0.3293

crop height curve shape coefficient b: -0.086

Specific stem silhouette area: 0.5878 lb/ft<sup>2</sup>

Specific stem silhouette area exponent: 1

specific leaf area: 4.096 lb/ft<sup>2</sup>

Heat units ratio to emergence: 0.05

starting leaf area at emergence: 0.465 in<sup>2</sup>/plant

Save Crop to Database OK Cancel

**Figure 7.35.** Size tab window.

Size tab (Fig 7.35): Miscellaneous types of crop architecture parameters are contained in this tab.

**Note:** Changing parameters on the 'Size' tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

The parameters are:

crop height curve shape coefficient a: The inflection point of a 2-parameter sigmoid function used to compute plant height.

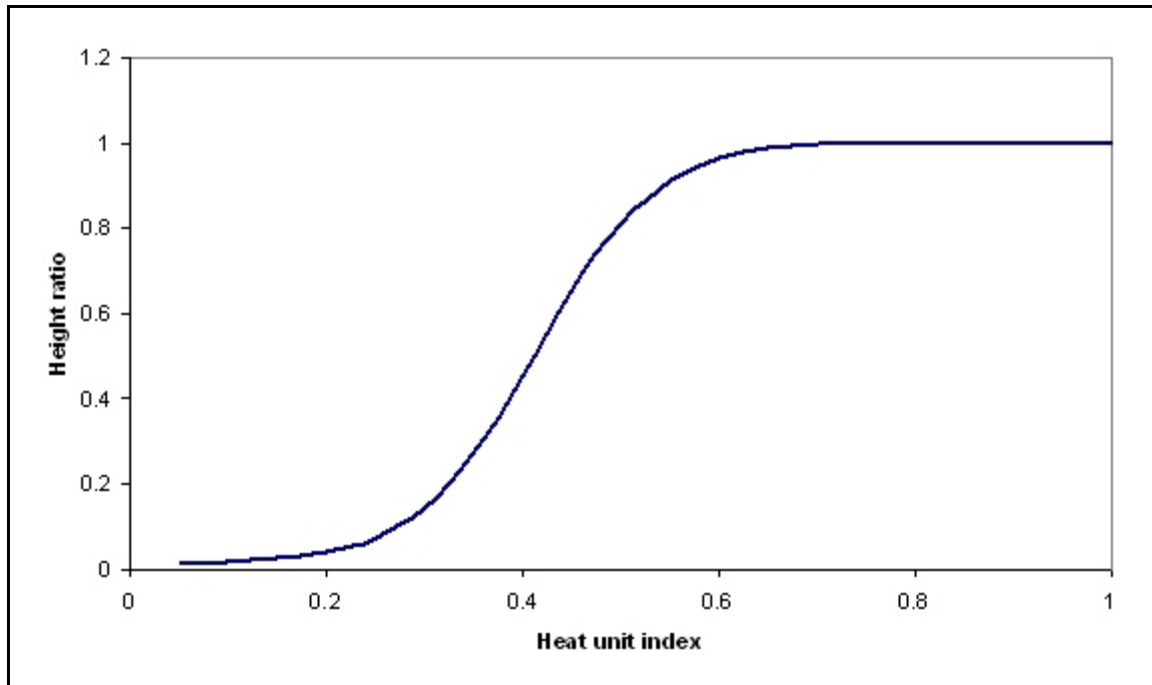
crop height curve shape coefficient b: The inverse of the slope of a 2-parameter sigmoid function used to compute plant height (Fig. 7.36). These two parameters determine the potential rate of increase in plant height of a crop. The parameters are the result of assuming that plant height growth follows the growth patterns in leaf area. However, these parameters can also be derived from field measured plant height data.

Specific stem silhouette area: A slope coefficient of a power function.

Specific stem silhouette area exponent: For many crops, for which field data are available, it has been found that the relationship of stem silhouette area to its mass is strongly correlated to a 2-parameter power function. The power function is used in the model to compute stem silhouette area. The parameters are the coefficients of the power function. These parameters can be determined from field data of stem mass and stem silhouette area.

specific leaf area: The slope of a linear regression line of leaf mass vs leaf area. A zero-intercept linear function relating leaf mass to leaf area is used in the model to convert leaf mass to leaf area. This parameter can be determined from field data of leaf mass and leaf area.





**Figure 7.36.** Sample graph of the function used to compute plant height.

Heat unit ratio to emergence: The relative heat units required for emergence. The model assumes that under average conditions it takes about 100 degree C days from seeding to emergence. The parameter is the ratio of degree C days from seeding to emergence to the degree C days from seeding to maturity.

starting leaf area per plant at emergence: The average estimated leaf area per plant when seedling emerges from the ground (inches<sup>2</sup>/plant).

**Figure 7.37.** Decomposition tab window.

Decomposition tab (Fig 7.37): Five options are available for selecting decomposition parameters for surface and buried residue. They range from fragile to non-erodible types depending on the crop type.

**Note:** Changing parameters on the ‘Decomposition’ tab is not recommended unless the user completely understands their derivation and the resulting effect of the changes. These parameters require extensive testing and or field data if new values are to be generated and used. Contact WERU for more assistance.

Parameters for each option are:

decomposition rate for standing stalks: Standing residue mass decomposition rate (g/g/day).

decomposition rate for surface residues: Flat residue decomposition rate (g/g/day).

decomposition rate for buried crop residue: Buried residue decomposition rate (g/g/day).

decomposition rate for roots: Root residue mass decomposition rate (g/g/day).

decomposition (fall) rate for standing stalks: The rate at which standing stalks fall to a flattened (horizontal) position on the soil surface.

average stem diameter: Residue stem diameter (meters or feet).

degree days threshold when stems begin to fall: Threshold degree C days (degree C days).

cover factor (mass to cover ratio):  $\text{kg m}^{-2}$

**Management Database**



# NOTES



